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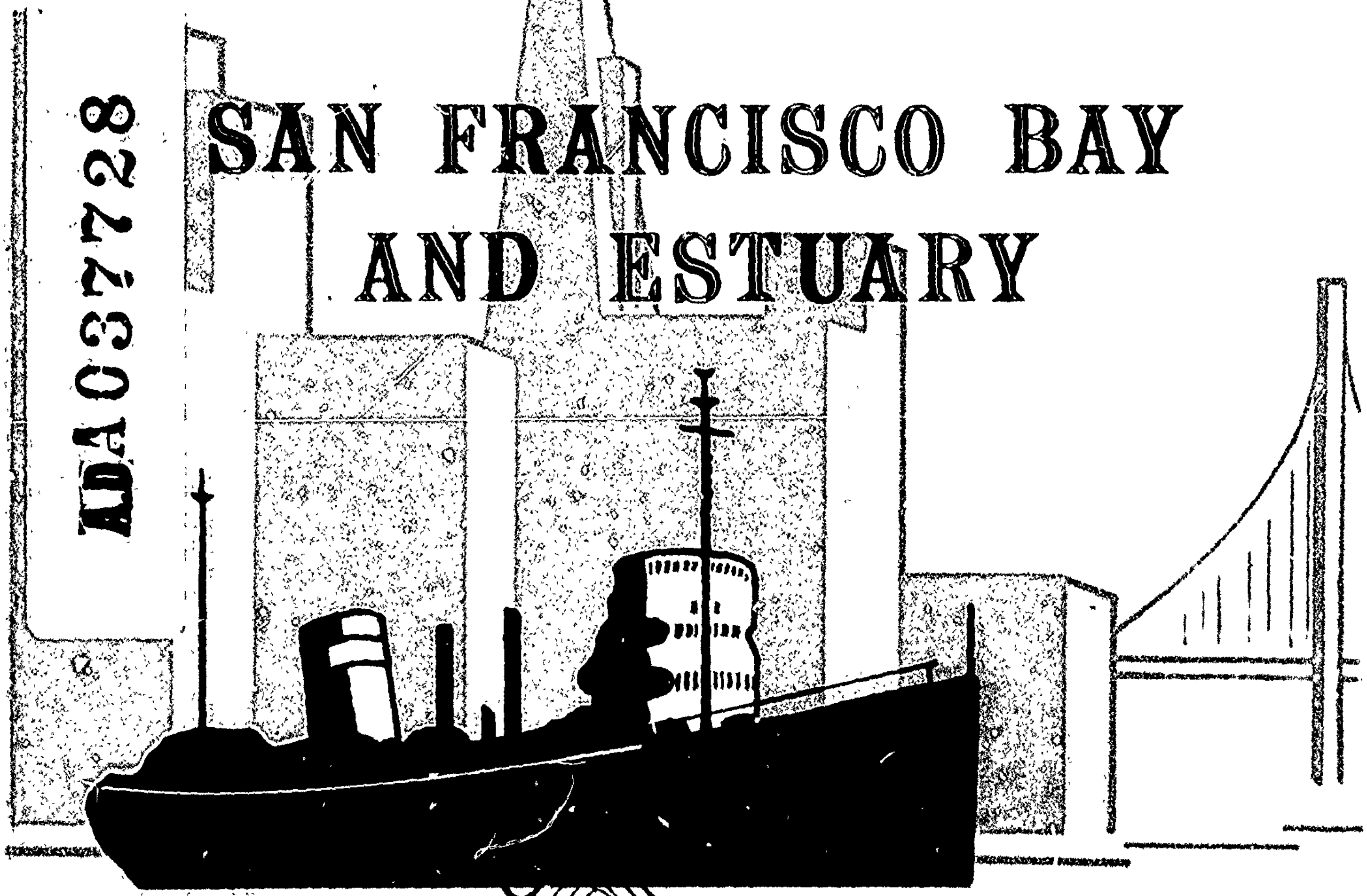
DREDGE DISPOSAL STUDY



SAN FRANCISCO BAY AND ESTUARY

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APPENDIX D

F A0375-12

BIOLOGICAL COMMUNITY

AUGUST 1975

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Sediment Quality
Estuary

20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The report presents sampling data on the infauna organisms in the Bay. Eleven stations were established in three project sites and four disposal areas. Five sampling periods over a period of one year were used to represent conditions ranging from high fresh water inflow in the winter to the dry period in late summer. In addition to the taxonomy, sediment analysis included temperature, pH, total sulfides, grain-size distribution and heavy metals - Cu, Cd, Zn, Pb and Hg. Water sample analysis included temperature, salinity, dissolved oxygen, pH, total sulfides and optical turbidity.

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DREDGE DISPOSAL STUDY SAN FRANCISCO BAY AND ESTUARY

APPENDIX D

BIOLOGICAL COMMUNITY STUDY

August 1975

U.S. Army Engineer District, San Francisco
Corps of Engineers
100 McAllister Street
San Francisco, California 94102

FOREWORD

In April 1972, the San Francisco District of the United States Army Corps of Engineers initiated a three and one-half year $3 million study to quantify the impact of dredging and dredged material disposal operations on the San Francisco Bay and Estuarine environment. The study is generating factual data, based on field and laboratory studies needed for the Federal, State and local regulatory agencies to evaluate present dredging policies and alternative disposal methods.

The study is set up to isolate the questions regarding the environmental impact of dredging operations and to provide answers at the earliest date. The study is organized to investigate (a) the factors associated with dredging and the present system of aquatic disposal in the Bay, (b) the condition of the pollutants (biogeochemical), (c) alternative disposal methods, and (d) dredging technology. The study elements are intended first, to identify the problems associated with dredging and disposal operations and, second, to address the identified problems in terms of mitigation and/or enhancement. The division into separate but inter-related study elements provides a greater degree of expertise and flexibility in the Study.

This report presents the findings of Appendix D, Biological Community. The overall study will be the basis for preparation of a composite Environmental Impact Statement for Dredging Activities in San Francisco Bay System. A draft final report on the entire study is scheduled for completion in December 1975.

The following is an index of appendices to be published in the Dredge Disposal Study:

APPENDIX	REPORT	DATE PUBLISHED
	FINAL REPORT	
A	Main Ship Channel (San Francisco Bar)	June 1974
B	Pollutant Distribution	
C	Water Column (Water Column-Oxygen Sag)	
D	Biological Community	August 1975
E	Material Release	
F	Crystalline Matrix	July 1975
G	Physical Impact	July 1975
H	Pollutant Uptake	
I	Pollutant Availability	
J	Land Disposal	October 1974
K	Marsh Development	
L	Ocean Disposal	
M	Dredging Technology	

CONVERSION FACTORS

If conversion from the Metric to the British system is necessary, the following factors apply:

LENGTH

1 kilometer (km)=10^3 meters=0.621 statute miles=0.540 nautical miles
1 meter (m)=10^2 centimeters=39.4 inches=3.28 feet=1.09 yards=0.547 fathoms
1 centimeter (cm)=10 millimeters (mm)=0.394 inches=10^4 microns (μ)
1 micron (μ)=10^{-3} millimeters=0.000394 inches

AREA

1 square centimeter (cm^2)=0.155 square inches
1 square meter (m^2)=10.7 square feet
1 square kilometer (km^2)=0.386 square statute miles=0.292 square nautical miles

VOLUME

1 cubic kilometer (km^3)=10^9 cubic meters=10^{15} cubic centimeters=0.24 cubic statute miles
1 cubic meter (m^3) =10^6 cubic centimeters=10^3 liters=35.3 cubic feet=264 U.S. gallons=1.308 cubic yards
1 liter=10^3 cubic centimeters=1.06 quarts=0.264 U.S. gallons
1 cubic centimeter (cm^3)=0.061 cubic inches

MASS

1 metric ton=10^6 grams=2,205 pounds
1 kilogram (kg)=10^3 grams=2.205 pounds
1 gr (g)=0.035 ounce

SPEED

1 knot (nautical mile per hour)=1.15 statute miles per hour=0.51 meter per second
1 meter per second (m/sec)=2.24 statute miles per hour=1.94 knots
1 centimeter per second (cm/sec)=1 97 feet per second

TEMPERATURE

Conversion Formulas $\quad {}^\circ C = \dfrac{{}^\circ F-32}{1.8} \qquad {}^\circ F = 1.8({}^\circ C) + 32$

PREFACE

The Biological Community Study was designed to expand present knowledge of the resident biota in San Francisco Bay with specific attention to areas which are or have been dredged or used for material disposal. The study was initiated with a preliminary survey in March 1973 to establish sampling locations and procedures for use in a year-long investigation. The objective of the year-long survey (September 1973 to June 1974) was to identify the indigenous infauna at selected stations and to document numerical fluctuations resulting from seasonal changes and interim dredging and disposal operations. A secondary objective of the investigation was to examine the biological and physical-chemical data (sediment and water) obtained during the survey to determine if biotic-abiotic relationships might exist.

The results of the initial surveys of the study were used by other investigators (Physical Impact, Appendix G; and Pollutant Uptake, Appendix H) to help in their selection of significant species in project areas for use in their studies. Additionally the results will be used in Environmental Impact Statements for fauna lists and directing any further studies of dredging and disposal impacts. The report also contains literature reviews of previous benthic surveys in the Bay and the toxicity of selected heavy metals.

Sections in the report (methods of heavy metal analyses, turbidity determinations and particle size evaluation) point out the difficulty of comparing measurements of chemical-physical parameters because of variability in techniques used. Methodolgy can be influenced by the availability of equipment and/or the investigator's preference for certain techniques because of project objectives.

The statistical analyses of the biotic-abiotic relationships, although interesting, cannot be interpreted absolutely. There are contradictions between what the analyses showed and what was observed in the field (e.g., the analyses found high salinity to be correlated with small populations where in the field the inverse was found to be true).

The results of this investigation will be integrated with the results for other biological (Physical Impact, Appendix G; Pollutant Uptake, Appendix H; and Pollutant Availability, Appendix I) and physical-chemical (Water Column, Appendix C; and, Crystalline Matrix, Appendix F) studies to evaluate the impact of dredging and disposal operations in San Francisco Bay.

ERRATA

Page xv, Nomenclatural Synonymies:

Spiophanes fimbriata ≠ S. missionensis ≠ S. berkeleyorum.

These names are not synonymous, but are names of three different species. For this report, however, only S. berkeleyorum applies. The other two species were not found during the study; rather, they were misidentifications. The names listed as synonymous are being used interchangeably in this report.

Pabe 6, Table 1:

ALC Alcatraz disposal site 37°49'27" (lat) 122°25'05" (long)

not 37°40'27" (lat) 122°25'55" (long)

Final Report May 1975

SAN FRANCISCO BAY BENTHIC COMMUNITY STUDY

Technical Evaluation

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CONTRACT DACW 07-74-C-0005

SRI Project LSU-2894 ✓

Approved by:

G. W. NEWELL, *Director*
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W. A. SKINNER, *Executive Director*
Life Sciences Division

ABSTRACT

SRI conducted a census of the benthic macrofauna in three dredged channels and four dredged-material disposal areas in San Francisco Bay in March, September, and December 1973 and in March and June 1974. During each of these periods, selected physical and chemical properties of the water and sediment were measured.

At Mare Island Strait, we established one sampling station in the dredged channel and another in the undredged portion of the Strait. At the Carquinez Strait disposal site, we fixed one station at the center of the site and another at the northern edge. Two stations each also were established at the South Bay disposal site and Redwood City Harbor. In March 1973, immediately after the first census, we had about 5,000 yd^3 of sediment transferred from one of the Redwood City Harbor stations to one of the South Bay disposal-site stations; no dredging or disposal activity occurred in either area during the remainder of the study.

Sediment from Mare Island Strait and the Carquinez Strait disposal site usually was inhabited by fewer taxa than sediment from other dredged channels or dredged-material disposal sites and oligochaetes predominated. At both sites, water salinity was usually low, turbidity was usually high, and other water quality characteristics were variable.

At different sampling times, the benthic animal population at the undredged portion of Mare Island Strait was about 2 to 300 times larger than that at the dredged portion of the Strait. At both areas, the largest number of animals was collected in September 1973.

The total number of taxa and specimens collected from the "disturbed," centrally located area of the Carquinez Strait disposal site and from the "undisturbed" area located at the northern edge differed little in September 1973. However, during every other

sampling period, the population at one of these areas was 4 to 7 times larger than that at the other. The population at the disturbed area peaked in June 1974, but, at the undisturbed area, it peaked in September 1973.

The largest number of taxa inhabited sediment from Oakland Inner Harbor, the Alcatraz disposal site, and the Hunters Point disposal site. At these Central Bay locations, the average water salinity was higher and the average water temperature was lower than at the other areas studied.

The largest total number of organisms was collected at Oakland Inner Harbor, where the animal population comprised principally polychaetes, oligochaetes, and molluscs. The density of the population was at least twice that of any other area during every sampling period except during June 1974, when the population decreased to 20% of that recorded in March 1974. The largest number of animals was collected in December 1973. The sediment at Oakland Inner Harbor contained very high levels of total sulfides and heavy metals at all times. The population decline in June corresponded to a near doubling of the sediment zinc concentration.

Most of the taxa found at the Alcatraz disposal site appeared to be transient types. About 85% of the total number of specimens were collected in September 1973, and about 81% of these specimens were Hesionura sp. In March of both years, the sediment was almost devoid of benthic animals.

The Hunters Point disposal site was inhabited primarily by arthropods and polychaetes. The largest number of animals was collected in September 1973. At this station, a little over half the total number of animals collected during the study were the arthropod Ampelisca milleri.

The water temperature in the southern area of San Francisco Bay averaged about one degree higher than at other areas studied; water salinity was intermediate; and sediment sulfide levels were relatively high. The South Bay disposal area was inhabited primarily by the arthropod Ampelisca milleri, the polychaete Exogone lourei, and various oligochaetes. In March 1973, before about 5,000 yd^3 of dredged sediment was disposed there, Station SB-A

was inhabited by fewer animals and taxa than the undisturbed station (SB-B). In September 1973, the population at SB-A was larger and more diverse than at SB-B. This picture reversed repeatedly in subsequent sampling months and did not appear to correspond to changes in the physical or chemical characteristics of the water or sediment.

Before sediment was removed from Station RCH-A at Redwood City Harbor, the benthic animal population was smaller and less diverse than at Station RCH-B, the control. During the next sampling period in September, the population at the dredged station increased by 124%, declined through March 1974, and peaked in June 1974. The population at the control station increased continuously between March 1973 and June 1974, but, the total number of animals collected was only about 57% of that collected at the dredged area. These differences and changes did not appear to correspond to any changes observed in the physical or chemical characteristics of the water or sediment.

Through analysis of regression coefficients obtained through application of the least-squares method, we concluded that the underlying relations among biological and environmental variables are complex and that additional field and laboratory studies would be required for thorough identification and understanding of such relationships.

The analysis did reveal some interesting trends. When considered separately, high water salinity and sediment mercury and sulfide concentrations were associated with small populations and low animal diversity; and high dissolved oxygen, turbidity, and sediment zinc and clay content were associated with large populations and great diversity of animals.

The analysis also indicated that the sediment at Mare Island Strait and the Carquinez Strait disposal site was less well populated than the sediment from Redwood City Harbor and the South Bay disposal site and that, at these four study areas, sediment at the disturbed stations tended to have less life than that from the undisturbed stations.

CONTENTS

ILLUSTRATIONS

TABLES

NOMENCLATURAL SYNONYMIES

Scientific names assigned to organisms occasionally are changed, and sometimes taxonomists disagree on the proper name for a given organism. Listed below are names that we believe are synonymous. All the names listed are used in this report. We considered it improper to change any of the names submitted to us by our consulting taxonomists or to change the names listed in the literature, even though they referred to the same animal.

The list below may be incomplete. It was constructed after discussion with our consulting taxonomists, and other taxonomists may not agree with this list.

- Polychaeta
  - *Trochochaeta multisetosum* = *Disoma multisetosum* = *D. franciscana*.
  - *Dorvillea annulata* = *Schistomeringus longicornis*.
  - *Nerine cirratulus* = *Scolelepis squamata*.
  - *Spiophanes fimbriata* = *S. missionensis* = *S. berkeleyorum*.
- Arthropoda
  - *Crago franciscorum* = *Crangon franciscorum*.
- Mollusca
  - *Ostrea gigas* = *Crassostrea gigas*.
  - *Ostrea virginica* = *Crassostrea virginica*.
  - *Venerupis phillipinarum* = *Tapes japonica* = *T. semidecussata* = *T. phillipinarum* = *T. decussatus* = *Venus japonica*.
  - *Musculus senhousia* = *Modiolus senhousia*.
  - *Macoma balthica* = *Macoma inconspicua*.

ACKNOWLEDGMENTS

We thank the taxonomic specialists who identified the benthic fauna collected during this study. These specialists were William Light of the California Academy of Sciences, who identified all the polychaetes and miscellaneous phyla of the preliminary survey and of Survey 1; Dr. Donald Reish and Michael Martin of California State University (Long Beach), who worked on the polychaetes and miscellaneous phyla collected during Surveys 2 through 4; Penny Pinter of the University of California, Berkeley, who was responsible for identifying all specimens in the phylum Ectoprocta; Barry Roth, California Academy of Sciences, who was in charge of identifying the molluscs; Ernest Iverson, also of the Academy, who identified the isopods, copepods, and tanaids collected during the preliminary survey; and John Chapman of the University of California, Berkeley, who identified all amphipods and miscellaneous arthropods collected during the investigation.

We also thank the following individuals who performed the tedious task of preliminary identification and counting of the animals after separating them from the washed debris: Karla Spangenberg, Martha Hill, Kathryn Storch, Katharine Jefferts, Robert Fish, Peter Busher, Thomas Adams, Daniel Ituarte, Dennis Tajiri, David Van Tresca, Janet Root, Michael Panietz, Dennis Leong, Janet Cross, Taffy Stewart, and Stewart Rowe. We also thank Christine Jong of the Moss Landing Marine Laboratory, who, because of her expertise in polychaete taxonomy, provided the taxonomic specialists with well-identified specimens that usually only required confirmation; Jean M. Lee and Howard Bailey for their assistance in organizing and evaluating the data; and Lorraine Watson for her help in the analysis of heavy metals.

INTRODUCTION

The benthic community study described herein is part of the Dredge Disposal Project sponsored by the Corps of Engineers, San Francisco District, to determine the environmental impact of dredging and disposal operations in San Francisco Bay.

The objective of the benthic community study was to collect "baseline" information on sediment-dwelling animals in three ship channels maintained by the Corps of Engineers and in four federally authorized disposal areas for dredged material in San Francisco Bay and Estuary. This information should provide a basis for evaluating future changes in the distribution and abundance of benthic animals and in certain physical and chemical properties of the water and sediment in these areas.

During the study, we collected replicate sediment and water samples from 11 sampling stations. The macrobenthic animals were removed from the sediment samples, identified, and counted. Temperature, pH, total sulfide content, heavy-metal content, and grain-size distribution were determined for the sediment samples; and the water samples were analyzed for temperature, salinity, dissolved oxygen content, total sulfide content, pH, and turbidity. We attempted to determine whether relationships existed between the physicochemical factors of the environment and the distribution and abundance of major animal groups.

In addition, we reviewed and summarized data from previous benthic-animal studies conducted in San Francisco Bay and data on the effects of heavy metals on benthic species found in the Bay.

The SRI study was performed in two phases, each under a separate contract. The principal objective of the preliminary phase (Contract No. DACW07-73-C-0059) was to establish the sampling stations, evaluate sampling and analytical methods, and provide the Corps of Engineers with an inventory of benthic species from which

to select types suitable for other laboratory studies planned for the Dredge Disposal Project. Field operations for the preliminary phase were performed in March 1973.

The definitive phase of the study was performed under Contract No. DACW07-74-C-0005. Field operations for this phase of the study were performed at three-month intervals between September 1973 and June 1974.

This report presents the results of both phases of the study. A literature review of previous benthic community studies and of the effects of heavy metals on benthic animals reportedly found in the Bay also is incorporated. The appendix, which contains the raw data, is available under separate cover.

STUDY APPROACH

Study Areas

Figure 1 shows the three ship channels and four disposal sites studied. The channels are maintained almost exclusively by the Corps of Engineers, and the disposal sites are used by the Corps of Engineers as well as by a number of private dredging companies.

Mare Island Strait is located in the tidewater of the Napa River. Because of heavy shoaling, the ship channel located along the western shore is dredged frequently, and the average volume of dredged material removed from the area is about 2,500,000 yd^3/yr.

Oakland Inner Harbor, located along the eastern shore of the central portion of San Francisco Bay, also is maintained heavily. About 500,000 yd^3 of sediment is removed yearly from the inner and outer harbor.

Located along the western shore of the southern portion of the bay, Redwood City Harbor is dredged less frequently than the other two ship channels, about 350,000 yd^3 of sediment being removed annually.

The Carquinez Strait disposal site is located along the southern tip of Mare Island. It receives most of the material removed from Mare Island Strait as well as material dredged from various adjacent, privately owned and maintained ship and boat docking areas.

The Alcatraz disposal site, located just south of Alcatraz Island, probably receives more dredged material than any other disposal site in the bay. The site is located over a deep (160-ft) depression and receives dredged material from numerous areas.

Study Approach
Study Areas

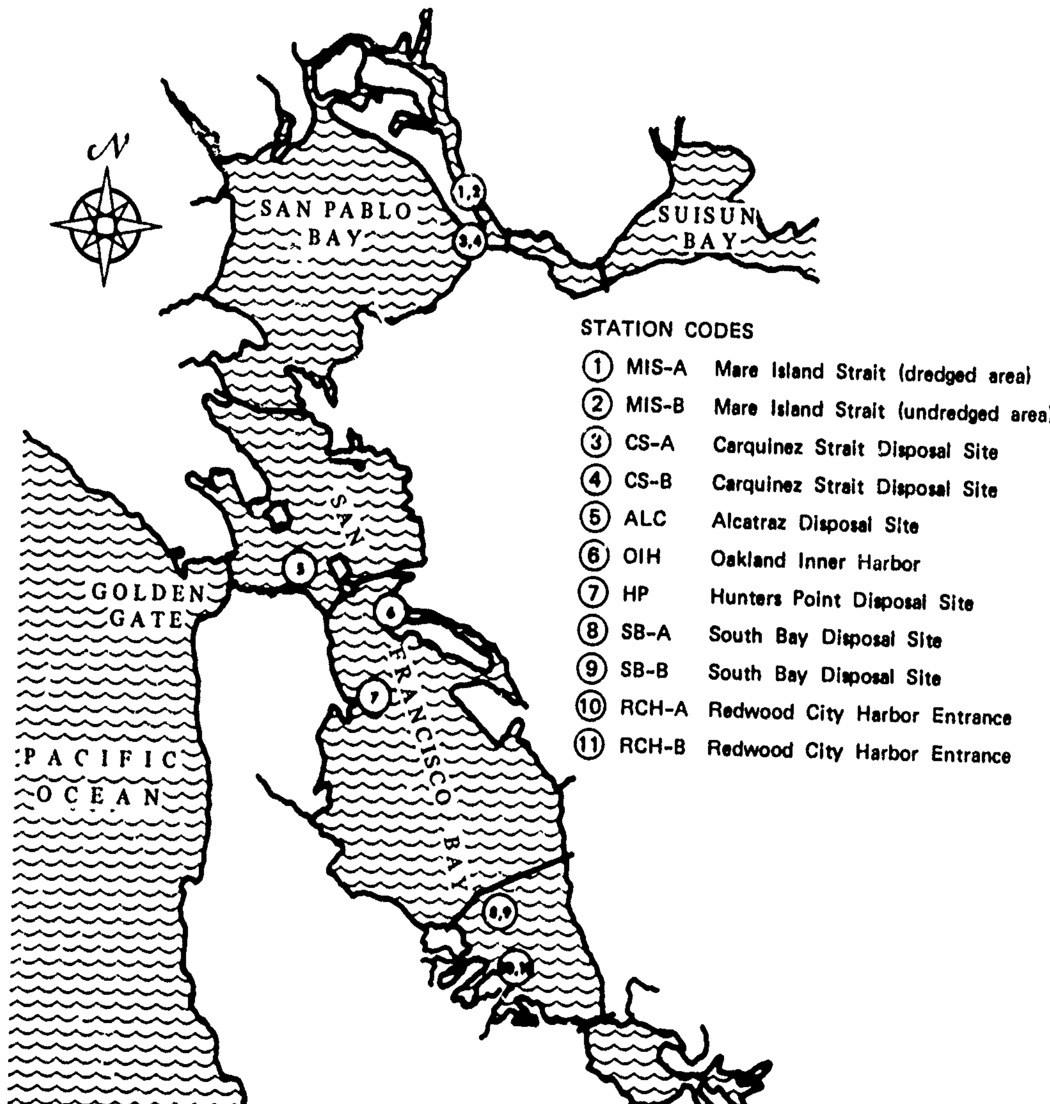


FIGURE 1 LOCATION OF SAMPLING STATIONS IN SAN FRANCISCO BAY

The Hunters Point disposal site is used infrequently. According to the Corps of Engineers, the last date of authorized use was March 1966. The South Bay disposal area, located south of the San Mateo bridge, is no longer used for disposal of dredged material.

Sampling Stations

Table 1 presents the location of the 11 sampling stations, the codes assigned to them, and the approximate depth at the sites. All stations, except the Alcatraz disposal site (Station ALC), were established during the preliminary phase of the study. The Corps of Engineers was most interested in obtaining information on the benthic fauna and the physical and chemical characteristics of the sediment and water from the deepest (160-ft) portion of the Alcatraz disposal site. However, our sampling efforts during the preliminary phase were unsuccessful because the boat could not be anchored in such deep waters. Hence, for the definitive phase of the study, we used a shallower (60-ft) sampling station near the western edge of the disposal site.

Because of the considerable dredging in the Mare Island Strait ship channel and disposal activity at the Carquinez Strait disposal site, we established two stations in each of these areas to determine whether the benthic communities or the physical and chemical characteristics of the sediment differed in disturbed and relatively undisturbed portions of the two areas. Thus, in Mare Island Strait, Station MIS-A was established in the center of the dredged channel, and Station MIS-B was established at a point along the eastern, undredged portion of the strait. At the Carquinez disposal site, Station CS-A was located near the center of the disposal area, and Station CS-B was established near the northern edge.

We established two stations also at the South Bay disposal site and at Redwood City Harbor so as to determine whether the benthic animals were affected by dredging or by disposal of dredged material. Stations SB-A and SB-B at the South Bay disposal site and Stations RCH-A and RCH-B at Redwood City Harbor were surveyed a total of five times during the investigation, as were all other stations. However, a few days after we collected samples from these four stations, we had the hopper dredge "Biddle" remove about

Table 1

LOCATION AND DESCRIPTION OF SAMPLING STATIONS

Station Code	Study Area	Station Location	Depth (ft)
MIS-A	Mare Island Strait ship channel	38° 05' 38" (lat), 122° 15' 33" (long.)	30-36
MIS-B	Mare Island Strait, eastern shore	38° 05' 42" (lat), 122° 15' 28" (long.)	20-36
CS-A	Carquinez Strait disposal site	38° 03' 49" (lat), 122° 15' 50" (long.)	48-50
CS-B	Carquinez Strait disposal site	38° 03' 57" (lat), 122° 15' 50" (long.)	40-48
ALC	Alcatraz disposal site	37° 40' 27" (lat), 122° 25' 55" (long.)	58-67
OIH	Oakland Inner Harbor ship channel	37° 20' 46" (lat), 122° 19' 04" (long.)	30-38
HP	Hunters Point disposal site	37° 44' 15" (lat), 122° 20' 30" (long.)	45-58
SB-A	South Bay disposal site	37° 34' 05" (lat), 122° 12' 33" (long.)	40-42
SB-B	South Bay disposal site	37° 34' 47" (lat), 122° 13' 45" (long.)	30-38
RCH-A	Redwood City Harbor entrance channel	37° 33' 03" (lat), 122° 11' 40" (long.)	24-47
RCH-B	Redwood City Harbor entrance channel	37° 32' 27" (lat), 122° 11' 32" (long.)	24-36

5,000 yd^3 of sediment from Station RCH-A and transfer it to Station SB-A. No dredging or disposal activity occurred in the vicinity of the four stations thereafter.

Sampling Schedule

Sediment and water samples were collected from each station at five different times during the period of performance. The first samples were collected in March 1973 during the preliminary phase. The other collections were conducted in September 1973, December 1973, March 1974, and June 1974 during the definitive phase.

Table 2 presents the day of the month, time of day, and the time of high and low tides for each survey. The sampling times are the times at which sampling was begun. In most instances, the samples at a given station were collected within about 30 minutes. The time of high and low tide was corrected for points in the Bay closest to the sampling station. The reference point for stations in Mare Island Strait and Carquinez Strait was the Mare Island Strait entrance. Alcatraz Island, Oakland Harbor (Grove Street), Point Avisadero, and the Redwood Creek entrance were reference points for stations at the Alcatraz disposal site, Oakland Inner Harbor, the Hunters Point disposal area, and Redwood City Harbor, respectively. Tide information for 1973 was supplied by tide tables of the U.S. Department of Commerce, Coast and Geodetic Survey; we obtained 1974 tide information from tide tables of the U.S. Department of Commerce, National Oceanic and Atmospheric Administration.

Except where indicated in Table 2, the tide times are for the day of sample collection. Tide times were selected to bracket the sampling time. In the table, high tide occurring earlier in the day than low tide indicates an outgoing tide, and high tide occurring later in the day than low tide indicates an incoming tide.

Table 2

SAMPLING SCHEDULE AND TIME OF HIGH AND LOW TIDES RELATIVE TO SAMPLING TIME
(Sampling Time in Parentheses)

	Survey														
	P (March 1973)			1 (Sept. 1973)			2 (Dec. 1973)			3 (March 1974)			4 (June 1974)		
	Date	Tide†		Date	Tide		Date	Tide		Date	Tide		Date	Tide	
Station	(Time)*	High	Low	(Time)	High	Low	(Time)	High	Low	(Time)	High	Low	(Time)	High	Low
MIS-A	3/14 (1718)	2309	1611	9/25 (1722)	1327	1921	12/17 (1615)	2022	1423	3/6 (1610)	1127	1754	6/3 (1800)	1347	1801
MIS-B	3/14 (1744)	2309	1611	9/28 (1145)	1503	0838	12/17 (1643)	2022	1423	3/6 (1705)	1127	1754	6/3 (1840)	0103‡	1801
CS-A	3/14 (1345)	0917	1611	9/25 (1405)	1327	1921	12/17 (1525)	2022	1423	3/6 (1450)	1127	1754	6/3 (1640)	1347	1801
CS-B	3/14 (1600)	0917	1611	9/25 (1515)	1327	1921	12/17 (1450)	2022	1423	3/6 (1410)	1127	1754	6/3 (1510)	1347	1801
ALC	3/19 (1435)	1214	1748	9/24 (1100)	1133	0430	12/18 (1235)	0647	1346	3/7 (1100)	1043	1657	6/4 (1330)	1330	1743
OIH	3/21 (1258)	1411	0730	9/20 (1030)	0833	1252	12/4 (0955)	0707	1339	3/4 (1140)	0805	1508	6/5 (1130)	0644	1435
HP	3/21 (1516)	1416	1915	9/20 (1230)	0838	1257	12/4 (1110)	0712	1344	3/4 (1315)	0805	1508	6/5 (1305)	0649	1440
SB-A	3/7 (1320)	1441	0810	9/19 (1015)	0809	1207	12/3 (1145)	0716	1333	3/5 (0910)	0953	0.31	6/6 (1020)	1600	0844
SB-B	3/7 (1625)	1441	2004	9/19 (0905)	0809	1207	12/3 (1100)	0716	1333	3/5 (1000)	0953	1636	6/6 (0905)	1600	0844
RCH-A	3/7 (1100)	1441	0810	9/19 (1125)	0809	1207	12/3 (1310)	0716	1333	3/5 (1105)	0953	1636	6/6 (1205)	1600	0844
RCH-B	3/7 (1542)	1441	2004	9/19 (1240)	1826	1207	12/3 (1350)	1904	1333	3/5 (1155)	0953	1636	6/6 (1105)	1600	0844

*Sampling start time (see text).
†Corrected time (see text).
‡Time given extended into the following day.

Sampling Procedures

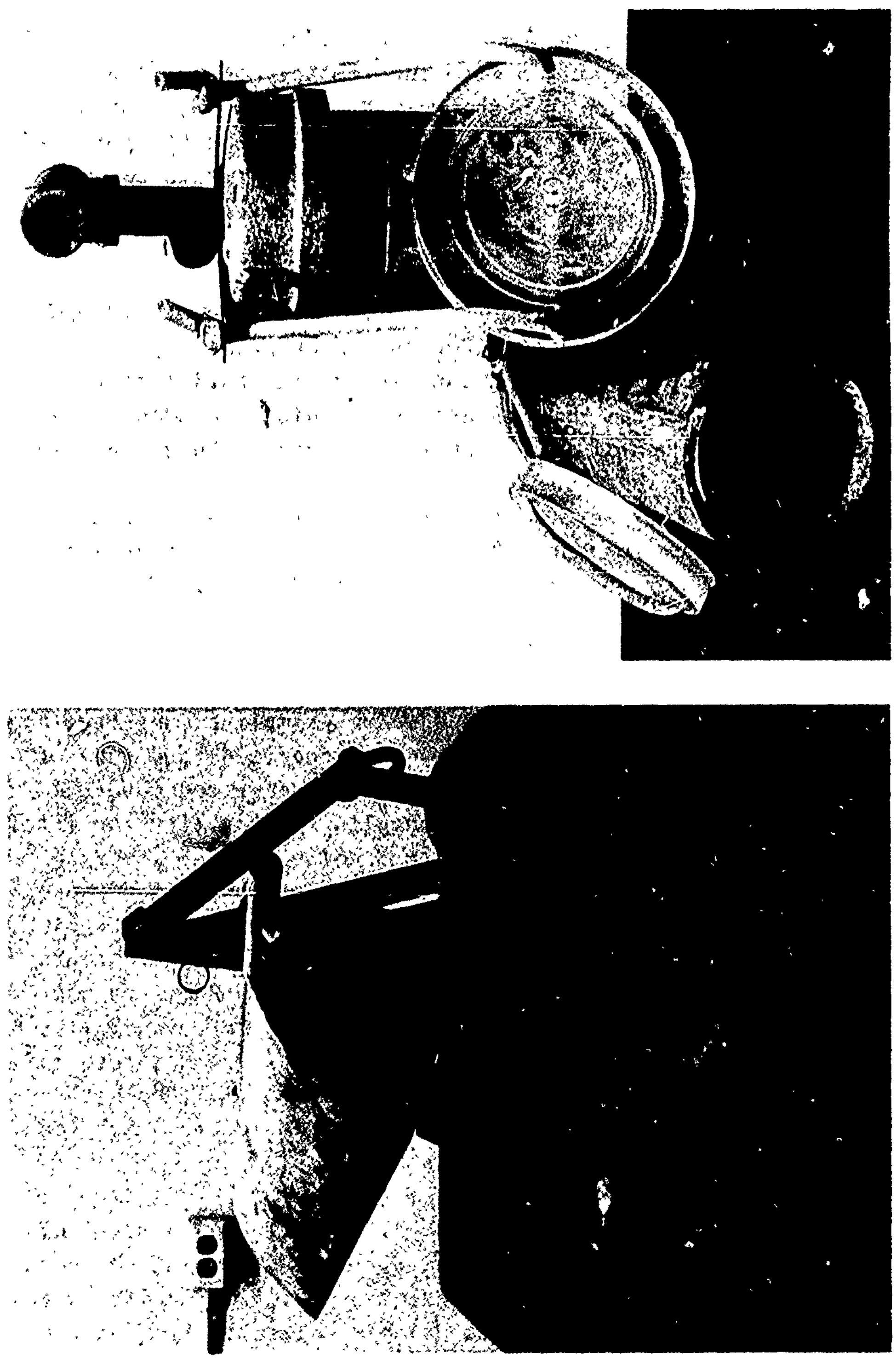
During the preliminary phase of the study, we collected sediment samples from all stations with the remotely controlled, 0.12-m^2 modified Petersen grab shown in Figure 2a. We also used diver-operated core samplers, shown in Figure 2b, at Stations OIH and HP. We used these two types of sampling devices to compare their performance and select one for use in the definitive phase of the study.

The modified Petersen grab is a clam-shell type of sediment sampler, differing from the true Petersen grab primarily in the design of the external arms that contain the triggering device. Thorsen (1957) discusses the advantages and disadvantages of the Petersen grab for quantitative sampling of macrobenthic organisms.

The core samplers were constructed of galvanized pipe and measured about 30 cm long and about 10 cm in diameter (inside). The divers used the rubber-tensioned plastic discs attached to the sampler (Figure 2b) to retain the sediment sample as the sampler was brought up through the water column.

Because of its greater area and volume-sampling capacity, the modified Petersen grab collected many more specimens and taxa of benthic animals per sample than did the diver-operated core samplers. However, Table 3 shows that sampling variability was little different relative to the number of taxa collected per liter of sediment. Both samplers collected about the same number of specimens per liter of sediment, but, with the modified Petersen grab, the number of specimens collected per liter varied less. At Station OIH, the amount of sediment collected by both samplers was about 67% of capacity, and the standard errors were essentially the same. At Station HP, where the sediment was softer, both samplers collected near-capacity volumes of sediment, although the amount of sediment in the replicate grab samples varied much less than in those collected by the core sampler.

Using the modified Petersen dredge, we collected a total of 75 taxa at Station OIH and 55 taxa at Station HP. Using the core sampler, the number of taxa collected at Stations OIH and HP were 31 and 22, respectively. Each grab sample collected from Station OIH contained an average of 50.4% of the total number of taxa found



(a) MODIFIED PETERSEN DREDGE SAMPLER

(b) CORE SAMPLERS

FIGURE 2 SEDIMENT SAMPLERS

Table 3

RELATIVE PERFORMANCE OF THE MODIFIED PETERSEN GRAB SAMPLER AND THE DIVER-OPERATED CORE SAMPLES
Based on Collection of Five Samples Using Each Sampler

	Station OIH		Station HP	
	Grab	Core	Grab	Core
Sample volume				
Mean	6.88	1.86	10.18	2.70
SE*	6.8	5.3	3.1	13.8
Taxa per liter				
Mean	544.92	143.72	64.30	22.22
SE	25.8	24.0	41.5	40.3
Specimens per liter				
Mean	5.46	6.90	2.20	2.62
SE	7.8	14.0	14.6	20.3

*Standard error in percentage of mean.

in all five grab samples; at Station HP, each grab sample contained 38% of the total number of taxa collected. Each core sample contained an average of 34.2 and 31.8% of the total number of taxa collected from Stations OIH and HP, respectively.

We concluded that, in terms of sampling reproducibility, both samplers were about equal. The core sampler might have enabled us to obtain samples of nearly equal size, to select each sampling spot, and to obtain more quantitative biological data. However, collection of core samples took about twice the time as collection of an equal number of grab samples, and the divers' safety was always in doubt. In addition, the divers were unable to observe the sampling operation--even under artificial illumination--and their

movements disturbed the sediment. Because of these problems, we selected the modified Petersen grab for use in the definitive phase.

Identification of Animals

The benthic animals were separated from the washed debris manually, preliminarily identified and counted, and then sent to taxonomic specialists for final identification and counting. Although we did attempt to identify each specimen to the specific level, we could not accomplish this task with all specimens. Identification of the nematodes, oligochaetes, nemerteans, copepods, ostracods, and cumaceans was especially difficult. As the study progressed, we did gain expertise in identifying the ostracods and cumaceans and, during the definitive phase, identified most of the specimens belonging to these two groups; however, throughout the study, specimens belonging to the other four groups were counted but not identified.

We limited identifications and counts to animals with heads. In the preliminary phase, we collected biological information from three to five sediment samples per station; during the definitive phase, we identified and counted animals extracted from three sediment samples per station. Table 4 shows the number of sediment samples processed for biological data.

Physical and Chemical Measurements

Measured Parameters

The temperature, pH, and color of each sediment sample were recorded immediately after sample collection. Subsamples of the sediment were analyzed later for total sulfides, grain-size distribution, and heavy metals (copper, cadmium, zinc, lead, and total mercury).

Water samples, which were collected within 3 ft of the bottom, were measured for temperature, salinity, dissolved oxygen, and pH

Table 4

NUMBER OF SEDIMENT SAMPLES PROCESSED DURING EACH SURVEY
TO OBTAIN CENSUSES OF THE BENTHIC POPULATIONS
Average Sample Volumes (Liters) are in Parentheses

	Survey				
Station	P (March 1973)	1 (Sept. 1973)	2 (Dec. 1973)	3 (March 1974)	4 (June 1974)
MIS-A	4 (10.0)	3 (9.6)	3 (10.3)	3 (10.4)	3 (9.8)
MIS-B	4 (10.1)	3 (10.5)	3 (11.1)	3 (10.3)	3 (10.7)
CS-A	5 (10.6)	3 (10.5)	3 (10.7)	3 (8.5)	3 (10.2)
CS-B	5 (9.7)	3 (10.1)	3 (10.0)	3 (10.4)	3 (9.3)
ALC	3 (6.2)	3 (7.5)	3 (7.8)	3 (9.8)	3 (8.1)
OIH	5 (7.4)	3 (11.3)	3 (8.3)	3 (8.3)	3 (10.2)
HP	5 (10.3)	3 (10.4)	3 (9.7)	3 (9.9)	3 (9.6)
SB-A	4 (11.0)	3 (11.2)	3 (10.4)	3 (10.3)	3 (11.6)
SB-B	5 (10.4)	3 (11.3)	3 (11.2)	3 (10.8)	3 (11.0)
RCH-A	5 (10.4)	3 (11.0)	3 (10.9)	3 (10.0)	3 (10.4)
RCH-B	5 (10.7)	3 (10.7)	3 (10.6)	3 (10.4)	3 (10.3)

immediately after collection. Total sulfide and turbidity determinations were conducted after the samples had been brought ashore.

Chemical Analytical Methods

Total Sulfides

The total sulfide content of the sediment and water samples was determined by the method described in the Chemistry Laboratory Manual - Bottom Sediments (EPA, 1969). By this method, we analyzed for dissolved hydrogen sulfide and its ionization products as well as for acid-soluble metallic sulfides. The sediment and water samples were treated with zinc acetate immediately after collection to precipitate the sulfides and prevent generation of H_2S during storage. During the preliminary phase of the study, we stored all samples reserved for chemical analysis in tightly capped glass jars but used heavy polyethylene jars during the definitive phase.

Dissolved Oxygen

The concentration of oxygen in the water samples was determined with a Yellow Springs dissolved oxygen meter (Model 54) immediately after sample collection. The water samples were transferred to BOD bottles with the transfer tube placed under the surface to minimize entry of air. The sensing electrode was equipped with a stopper designed to prevent entry of air during stirring of the samples. A magnetic stirrer was used during analysis.

pH

We determined the pH of the water and sediment samples with a Beckman pH meter (Model 76) immediately after the samples were collected.

Salinity

During the preliminary phase, we measured salinity with Yellow Springs salinometer (Model SC-T). However, during the definitive phase, we used a refractometer (American Optical) because it provided more reproducible readings. To obtain a sample of interstitial water for analysis, we extracted the water from the sediment by centrifugation. Interstitial water salinity was determined only during the March and June 1974 surveys.

Heavy Metals

We conducted exploratory studies using two analytical methods for copper, cadmium, lead, and zinc. The methods differ only in the procedures used for treating samples before actual metal analysis by atomic absorption. The method recommended by EPA (EPA, 1969) involves sediment acidification, high-temperature (400 to 425°C) ashing, and acid extraction. The method of Mathis and Cummings (1971) involves drying the sample to constant weight, acid digestion, and filtration. Heavy-metal analysis was performed on a Varian Tektronic atomic absorption spectrophotometer (Model AA-6).

We chose to use the method of Mathis and Cummings because it gave higher yields than the EPA method. The difference in yields was especially evident with lead, as shown in Table 5, and was probably due to volatilization of metals during high-temperature ashing in the EPA method.

We explored the efficiency of the Mathis and Cummings method by determining heavy-metal recovery from spiked sediment. Table 6 presents the results. The mean values for percentage of recovery were used to adjust the measured concentrations of lead, cadmium, copper, and zinc in sediment samples analyzed.

The method used for the analysis of mercury was the one recommended for water, biological tissues, and mud by the EPA Analytical Quality Control Laboratory, Cincinnati, Ohio (EPA, 1971). This method involves reducing mercury compounds to elemental mercury

Table 5

EFFECT OF EXTRACTION METHOD ON RECOVERY
OF HEAVY METALS FROM BOTTOM SEDIMENTS

Sample	Method	Micrograms of Metal Found per Gram of Dry Sediment			
		Lead	Cadmium	Copper	Zinc
1	EPA	0	1.08	23.90	30.0
	Mathis	35.48	1.41	49.67	32.3
2	EPA	7.36	0.29	6.32	18.5
	Mathis	27.64	1.10	38.17	22.1

Table 6

RECOVERY OF HEAVY METALS FROM SPIKED SEDIMENT SAMPLES USING THE MATHIS AND CUMMINGS METHOD (1971)

Sample	Initial Finding (μg)	Added (μg)	Recovered (μg)	Recovery (%)
Lead				
1	175	500	500	74
2	175	500	562	83
3	275	100	425	114
4	485	100	538	92
5	335	100	412	95
6	290	100	350	90
Mean				91.33
Cadmium				
1	0	30	35	119
2	2.3	30	31	96
3	11.6	100	125	112
4	20.0	100	130	108
5	16.0	100	135	116
6	13.0	100	130	115
Mean				111.0
Copper				
1	283	280	625	111
2	104	280	365	95
3	395	100	575	116
4	498	100	562	94
5	715	100	750	92
6	569	100	762	114
Mean				103.66
Zinc				
1	790	30	772	94
2	710	30	622	84
3	1,088	100	1,520	128
4	1,544	100	1,595	97
Mean				100.75

by reaction with various reagents, then sweeping the mercury vapor through a cell positioned in the light path of an atomic absorption at 253.7 nm.

As shown in Table 7, testing with sediment samples spiked with inorganic mercury produced low recoveries, averaging 42%. We did not determine recovery from samples spiked with organic mercury and did not explore other analytical methods. The poor recovery of mercury was probably due to loss of ionic mercury during the overnight acid digestion step necessary with actual sediment samples. Because recovery from actual samples may be higher than that from spiked samples, we did not apply a correction factor to the data.

Table 7

RECOVERY OF MERCURY FROM SEDIMENT SPIKED WITH INORGANIC MERCURY

Sample	Initial Hg Finding (μg)	Added (μg)	Recovered (μg)	Recovery (%)
1	0.1050	1.0	0.56	51
2	4.5000	5.0	3.20	34
3	8.7000	5.0	4.95	36
4	0.7000	1.0	0.80	47

Measurement of Physical Parameters

Sediment Particle-Size Distribution

Sediment particle-size distribution was determined by wet and dry sieving and by liquid sedimentation techniques. In the preliminary phase, we treated the sediment samples with hydrogen peroxide (30%) to oxidize the organic material and added sodium

hexametaphosphate as a dispersing agent. Treatment of the samples with these two chemicals is recommended by Holme and McIntyre (1971). We characterized the sediment into five size categories--namely, 499, 125-499, 62-124, 4-61, and <4 μ--and performed the liquid sedimentation analysis in graduate cylinders immersed in a constant-temperature water bath.

For the definitive phase, we decided a more thorough analysis was necessary and subsequently analyzed the sediment using 12 size categories. We oven dried the wet-sieved fraction, which contained particles larger than 43 μ, and subfractionated this fraction into five size categories using a nest of Ro-Tapped Tyler sieves. The pan fraction (>43 μ) was added to the fraction reserved for liquid sedimentation analysis.

Liquid sedimentation analysis for samples collected during the definitive phase was performed in vacuum-jacketed glass columns designed at SRI specifically for analysis of particle size. Particles subjected to liquid sedimentation analysis were sized according to Stoke's Law regarding the time required for particles for a given size and shape to fall a specific distance through a viscous fluid. Samples removed from the column were collected on preweighed, 0.8-μ Millipore filters. The collected sediment and filters were oven dried and weighed, and the sample weight was recorded after subtraction of the filter weight. After each sample was taken from the column, the column was refilled with water and inverted several times to redisperse the particles. Samples analyzed during the definitive phase were not treated with hydrogen peroxide or sodium hexametaphosphate.

Turbidity

Turbidity measurements were performed according to procedures described in <u>Standard Methods</u> (1971), but the nephelometer described in that manual was not employed. We used a Bausch and Lomb spectrophotometer (Spectronic 20) that, instead of measuring the intensity of light scattered at right angles to the path of incident light, measures the intensity of light passing through the sample.

Turbidity values were obtained by comparing the percentage of light transmittance of mercuric chloride-treated water samples with that of a standard formazin suspension. The values are reported in nephelometric units (NU), which are similar but not identical to Jackson turbidity units (JTU). Our nephelometric values may not be comparable to those that might have been obtained if the recommended type of nephelometer had been used; however, they do indicate the relative differences in water turbidity among stations and sampling periods.

Temperature

Sediment and water temperature were measured with a glass thermometer.

RESULTS AND DISCUSSION

Biological Characteristics

Each of the seven dredged and disposal areas investigated contained unique benthic communities that generally differed in composition and animal numbers. Although many different organisms were found at each station, few could be considered abundant or common. In this report, we have classified as "abundant" those organisms comprising 1% or more of the total number of noncolonial specimens collected at a given station during the study; "common organisms" are those that were found during all five sampling months, regardless of their abundance.

Some of the fauna collected during the study were colonial types, the Ectoprocta being examples. Other colonial types were the sponges (Porifera) and certain kinds of cnidarians and chordates. We did not determine the number of individuals in each colony, as this would have been a formidable and fruitless task, nor did we count colonies, as this would have produced meaningless data because the colonies tend to disintegrate upon handling. In the tables in this section, the letter "P" denotes "present," indicating that a colonial organism was found.

Mare Island Strait

Station MIS-A

Table 8 presents the taxa and number of specimens collected during each of the five surveys. The total numbers of taxa and noncolonial specimens collected during each survey are shown at the bottom of the table.

At Station MIS-A, we identified 33 taxa, of which 5 were colonial and 28 were noncolonial. A total of 9,212 specimens were

Table 8

DISTRIBUTION AND ABUNDANCE OF SPECIES AT STATION MIS-A

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY					SPECIMEN TOTAL
	SURVEY					
	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	
PROTOZOA						
VORTICELLA SP.	--	--	--	--	P	P
CNIDARIA						
HYDROZOA-UNIDENTIFIED SPP.	--	P	P	--	P	P
CAMPANULARIA SP.	--	--	P	--	--	P
NEMATODA						
NEMATODA-UNIDENTIFIED SPP.	7	269	61	23	93	453
ANNELIDA-OLIGOCHAETA						
OLIGOCHAETA-UNIDENTIFIED SPP.	9	7508	259	11	197	8044
ANNELIDA-POLYCHAETA						
STREBLOSPIO BENEDICTI	--	33	1	1	--	35
HAPLOSCOLOPLUS PUGETTENSIS	--	1	--	--	--	1
ETEONE LIGHTI	--	13	1	--	--	14
NEANTHES SUCCINEA	--	1	--	--	--	1
PSEUDOPOLYDORA KEMPI CALIFORNICA	--	1	--	--	--	1
EXOGONE LOUREI	--	--	1	--	--	1
ETEONE LONGA CALIFORNICA	--	--	1	--	--	1
ARTHROPODA						
COPEPODA-UNIDENTIFIED SPP.	95	114	279	16	23	527
OSTRACODA-UNIDENTIFIED SPP.	1	--	--	--	--	1
BALANUS CRENATUS	1	--	--	--	--	1
MYSIDACEA-UNIDENTIFIED SPP.	3	--	--	--	--	3
AMPELISCA MILLERI	--	14	--	1	1	16
GRANDIDIERELLA JAPONICA	--	1	--	--	--	1
INSECTA-UNIDENTIFIED SPP.	--	1	1	1	--	3
SYNIDOTEA LATICAUDA	--	--	1	--	--	1
BALANUS SP.	--	--	1	--	--	1
ARACHNIDA-UNIDENTIFIED SPP.	--	--	--	--	1	1

Table 8 (Concluded)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY — SURVEY P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	SPECIMEN TOTAL
MOLLUSCA						
MACOMA BALTHICA	11	33	10	--	17	71
MACOMA NASUTA	1	--	--	--	--	1
MYA ARENARIA	4	3	2	--	--	9
NASSARIUS OBSOLETUS	--	8	3	--	--	11
ODOSTOMIA (EVALEA) SP. A	--	6	--	--	--	6
MUSCULUS SENHOUSIA	--	--	5	--	--	5
GEMMA GEMMA	--	--	1	--	--	1
ODOSTOMIA (MENESTHO) FETELLA	--	--	1	--	--	1
ODOSTOMIA (EVALEA) FRANCISCANA	--	--	--	--	1	1
ECTOPROCTA						
CHEILOSTOMATA-UNIDENTIFIED SPP.	P	--	--	--	--	P
MEMBRANIPORA PERFRAGILIS	P	P	P	P	P	P
GRAND TOTALS						
SPECIMENS	132	8066	628	53	333	9212
TAXA	11	17	19	7	10	33

collected. Twenty-five of the noncolonial taxa were relatively rare, the number of specimens representing them amounting to about 2% of the total number of noncolonial specimens collected as MIS-A.

Table 9 lists the five abundant taxa, which accounted for 97.9% of the five-survey noncolonial specimen count. Because of the differences in sample numbers and volumes collected during each survey, the data in Table 9 are presented as specimens per liter of sample. Although benthic animal densities usually are presented as specimens per unit area, we believe that density so expressed is valid only when samples of equal volume are collected and when investigators can control carefully the depth and angle that the sampling device enters the sediment. We could not meet these criteria using the remotely controlled Petersen grab.

Table 9

CONCENTRATIONS OF THE MOST ABUNDANT
BENTHIC ORGANISMS COLLECTED AT STATION MIS-A
(Individuals per Liter)

	Percentage of Population*	Survey P (3/73)	Survey 1 (9/73)	Survey 2 (12/73)	Survey 3 (3/74)	Survey 4 (6/74)
Nematoda	4.9%	0.18	9.34	1.97	0.74	3.16
Oligochaeta	87.3	0.22	262.78	8.38	0.35	6.70
Arthropoda						
Copepoda	5.7	2.38	3.96	9.03	0.51	0.78
Total	97.9%	2.78	276.08	19.38	1.60	10.64
All organisms†	100.0	3.30	280.07	20.32	1.70	11.33

*Numerical percentage of all noncolonial organisms collected.

†All noncolonial organisms collected.

As shown in Table 9 the population density for all noncolonial animals was greatest in September 1973 (Survey 1), and oligochaetes predominated. The population density was about 14 times greater in September 1973 than during any other sampling period. In March 1973 and 1974, we encountered the fewest number of animals per liter. In March 1973 (Survey P), copepods primarily composed the population, whereas in March 1974 (Survey 3), the nematodes were slightly more numerous. The nematodes were most abundant in September 1973. Many nematodes, copepods, and perhaps some oligochaetes are not retained by a size-30 screen, so that the data for these taxa may not be quantitative.

In December 1973 (Survey 2), the population density was 20.32 noncolonial animals per liter, and oligochaetes and copepods predominated. In June 1974 (Survey 4), we collected 11.33 noncolonial animals per liter, and at least half the number were oligochaetes.

Seven species of polychaetes were collected at MIS-A (see Table 8). All were collected in September and December 1973 and March 1974. In September, five species were taken, representing 49 specimens, 33 of which were *Streblospio benedicti*. This small worm was the most abundant polychaete encountered during the study. In December, we collected single specimens of four polychaete species, two of which were new; in March 1974, only one polychaete specimen (*Streblospio benedicti*) was found.

We collected 10 different kinds of arthropods from MIS-A. The abundant copepods were present during each sampling month, and other arthropods, represented by 28 individuals, appeared sporadically. Of the nine species of mollusc collected, only the clam *Macoma balthica* occurred with any frequency or abundance. Of the 106 molluscs encountered, 71 were of this species. Molluscs were absent in March 1974.

Station MIS-B

At Station MIS-B, the sediment samples contained fewer species (26) than those from MIS-A; however, the population was about six times larger, as shown in Table 10. Numerically, the

Table 10

DISTRIBUTION AND ABUNDANCE OF SPECIES AT STATION MIS-B

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY: P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	SPECIMENS TOTAL
CNIDARIA						
HYDROZOA-UNIDENTIFIED SPP.	--	--	P	--	P	P
NEMATODA						
NEMATODA-UNIDENTIFIED SPP.	7	243	25	184	135	594
ANNELIDA-OLIGOCHAETA						
OLIGOCHAETA-UNIDENTIFIED SPP.	232	15122	14875	11714	11925	53868
ANNELIDA-POLYCHAETA						
STREBLOSPIO BENEDICTI	5	282	521	119	135	1062
NEANTHES SUCCINEA	--	3	2	5	7	17
ETEONE LIGHTI	--	26	--	--	4	30
PSEUDOPOLYDORA KEMPI CALIFORNICA	--	5	5	--	--	10
HETEROMASTUS FILIFORMIS	--	1	--	--	--	1
EXOGONE SP.	--	--	1	--	--	1
SIPUNCULA						
SIPUNCULA-UNIDENTIFIED SPP.	--	--	--	1	--	1
ARTHROPODA						
COPEPODA-UNIDENTIFIED SPP.	13	19	35	91	48	206
MYSIDACEA-UNIDENTIFIED SPP.	1	--	--	--	--	1
AMPELISCA MILLERI	3	9	--	--	--	12
AMPHIPODA-UNIDENTIFIED SPP.	1	--	--	--	--	1
INSECTA-UNIDENTIFIED SPP.	1	--	--	--	1	2
PYCNOGONIDA-UNIDENTIFIED SPP.	--	--	1	--	--	1
GRANDIDIERELLA JAPONICA	--	--	1	--	--	1
MELITA SP.	--	--	2	--	--	2
MOLLUSCA						
MYA ARENARIA	20	22	31	13	6	92
MACOMA BALTHICA	63	41	23	20	46	193
NASSARIUS OBSOLETUS	6	--	73	--	--	79
GEMMA GEMMA	--	--	1	--	--	1

Table 10 (Concluded)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY					SPECIMENS TOTAL
	SURVEY					
	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	
MUSCULUS SENHOUSIA	--	--	--	1	--	1
UDOSTOMIA (MENESTHO) FETELLA	--	--	--	1	--	1
PELECYPODA-UNIDENTIFIED SPP.	--	--	--	1	--	1
ECTOPROCTA						
MEMBRANIPORA PERFRAGILIS	P	P	P	P	--	P
GRAND TOTALS						
SPECIMENS	352	15773	15596	12150	12307	56178
TAXA	12	12	16	12	10	26

population at MIS-B was relatively stable between September 1973 and June 1974 when the average number of specimens collected during each sampling period was 13,956, and the range was from 12,150 to 15,773. In March 1973, we collected only 352 specimens.

This undredged area of Mare Island Strait was inhabited almost exclusively by oligochaetes. Table 11 reflects the heavy influence of the oligochaetes relative to the population density values for all species. Numerical changes in the sampling returns for each survey resulted primarily from fluctuations in the number of these worms. In September and December 1973 and in March and June 1974, the oligochaetes comprised 95.9, 95.4, 96.4, and 96.9%, respectively, of the total number of noncolonial specimens collected. In March 1973, 65.9% of the specimens were oligochaetes.

Table 11

CONCENTRATIONS OF THE MOST ABUNDANT
BENTHIC ORGANISMS COLLECTED AT STATION MIS-B
(Individuals per Liter)

	Percentage of Population*	Survey P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)
Nematoda	1.1%	0.17	7.71	0.75	5.95	4.21
Oligochaeta	95.9	5.74	480.06	446.70	379.09	371.50
Polychaeta						
S. benedicti	1.9	0.12	8.95	15.64	3.85	4.21
Total	98.9%	6.03	496.72	463.09	388.89	379.92
All organisms†	100.0	8.71	500.73	468.35	393.20	383.40

*Numerical percentage of all noncolonial organisms collected.

†All noncolonial organisms collected.

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Table 11

CONCENTRATIONS OF THE MOST ABUNDANT
BENTHIC ORGANISMS COLLECTED AT STATION MIS-B
(Individuals per Liter)

	Percentage of Population*	Survey P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)
Nematoda	1.1%	0.17	7.71	0.75	5.95	4.21
Oligochaeta	95.9	5.74	480.06	446.70	379.09	371.50
Polychaeta						
S. benedicti	1.9	0.12	8.95	15.64	3.85	4.21
Total	98.9%	6.03	496.72	463.09	388.89	379.92
All organisms†	100.0	8.71	500.73	468.35	393.20	383.40

*Numerical percentage of all noncolonial organisms collected.

†All noncolonial organisms collected.

Island Strait, but it was not as densely populated. We collected 47 species of benthic animals at Station CS-A. Table 12 presents these species and their abundance during the five sampling periods. Nine of the species from this station were colonial types.

A total of 8,450 noncolonial specimens were collected at CS-A, approximately 97% of them belonging to six taxa. Table 13 lists the taxa and the density of each. The oligochaetes predominated during all five surveys; about 66% of all noncolonial specimens encountered at this station were oligochaetes. About 74% of the 5,569 oligochaetes taken during the study were obtained in June 1974; they were least abundant in March 1973, when only 53 specimens (1/liter) were recovered.

The nematodes were the second most numerous animals, primarily because of a sudden increase in their numbers in June 1974, accounting for 16.4% of the total noncolonial specimen count at CS-A.

The polychaetes comprised 14 species, represented by 854 specimens, 10.1% of the total specimen count. The most abundant polychaete was Streblospio benedicti, which was present during all five surveys but was not particularly abundant in March of both years (seven were collected in March 1973, and only one was taken in March 1974). The largest number, 469, was collected in December 1973, and a relatively large number, 181, was collected in June 1974.

The arthropods comprised 14 species. In general, we did not encounter many arthropods at CS-A, the number found representing only 3.5% of the total noncolonial specimen count. About 88% of the arthropods were found in September; most of them were Balanus improvisus, a barnacle, found attached to a single rock. In contrast to their abundance at the Mare Island Strait area, copepods were not abundant at Carquinez Strait. The five-survey total for CS-A was three.

Molluscs constituted about 4.1% of the total specimen count. We collected seven species, five of them during the preliminary survey of March 1973. The remaining two were captured

Table 12

DISTRIBUTION AND ABUNDANCE OF SPECIES AT STATION CS-A

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY					SPECIMEN TOTAL
	SURVEY					
	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	
CNIDARIA						
HYDROZOA-UNIDENTIFIED SPP.	P	--	--	--	--	P
GONOTHYRAEA SP.	--	P	--	--	--	P
CAMPANULARIA SP.	--	--	P	--	P	P
NEMATODA						
NEMATODA-UNIDENTIFIED SPP.	9	45	27	37	1267	1385
ANNELIDA-OLIGOCHAETA						
OLIGOCHAETA-UNIDENTIFIED SPP.	53	387	846	169	4114	5569
ANNELIDA-POLYCHAETA						
HETEROMASTUS FILIFORMIS	1	--	1	1	4	7
STREBLOSPIO BENEDICTI	7	83	469	1	181	741
ETEONE LIGHTI	1	2	10	--	18	31
GLYCINDE SP.	--	18	7	3	4	32
NEANTHES SUCCINEA	--	2	--	1	3	6
POLYDORA LIGNI	--	4	5	--	--	9
THARYX PARVUS	--	2	1	--	1	4
CAULLERIELLA HAMATA	--	1	--	--	--	1
POLYDORA CAULLERYI	--	1	--	--	--	1
EXOGONE LOUREI	--	1	--	--	--	1
ETEONE LONGA CALIFORNICA	--	--	3	--	--	3
PSEUDOPOLYDORA KEMPI CALIFORNICA	--	--	3	--	1	4
CHAETOZONE SP.	--	--	6	--	--	6
THARYX SP.	--	--	6	--	2	8
ARTHROPODA						
MYSIDACEA-UNIDENTIFIED SPP.	1	--	--	--	--	1
SYNIDOTEA LATICAUDA	1	--	--	--	1	2
PARAPHOXUS MILLERI	--	9	--	10	--	19
HYPERIIDEA-UNIDENTIFIED SPP.	--	1	--	--	--	1
COPEPODA-UNIDENTIFIED SPP.	--	1	--	2	--	3
AMPELISCA MILLERI	--	2	1	--	--	3
BALANUS IMPROVISUS	--	245	--	--	--	246

Table 12 (Concluded)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY P (3/73)	SURVEY 1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	SPECIMEN TOTAL
LEPTOCHELIA DUBIA	--	1	--	--	--	1
GRANDIDIERELLA JAPONICA	--	1	8	--	--	9
DECAPODA-UNIDENTIFIED SPP.	--	--	--	1	--	1
HALACARIDAE-UNIDENTIFIED SPP.	--	--	--	1	--	1
BALANUS SP.	--	--	--	1	--	1
BALANUS CARIOSUS	--	--	--	6	--	6
INSECTA-UNIDENTIFIED SPP.	--	--	--	--	2	2
MOLLUSCA						
NASSARIUS OBSOLETUS	41	--	8	1	--	50
MYA ARENARIA	39	22	10	63	5	139
MACOMA BALTHICA	36	10	6	--	95	147
MYTILUS EDULIS	1	--	--	2	--	3
TAPES JAPONICA	2	--	1	--	--	3
MUSCULUS SENHOUSIA	--	1	--	1	--	2
ODOSTOMIA (MENESTHO) FETELLA	--	--	1	--	--	1
ECTOPROCTA						
MEMBRANIPORA PERFRAGILIS	P	P	--	P	P	P
CHEILOSTOMATA-UNIDENTIFIED SP. A	P	--	--	--	--	P
CHEILOSTOMATA-UNIDENTIFIED SP. B	P	--	--	--	--	P
CONOPEUM RETICULUM	--	--	--	P	P	P
MEMBRANIPORA VILLOSA	--	--	--	--	P	P
ELECTRA ARCTICA	--	--	--	--	P	P
ENIGMATICA						
ENIGMATICA	--	1	--	--	--	1
GRAND TOTALS						
SPECIMENS	192	841	1419	300	5698	8450
TAXA	16	24	20	18	19	47

Table 13

CONCENTRATIONS OF THE MOST ABUNDANT
BENTHIC ORGANISMS COLLECTED AT STATION CS-A
(Individuals per Liter)

	Percentage of Population*	Survey P (3/73)	Survey 1 (9/73)	Survey 2 (12/73)	Survey 3 (3/74)	Survey 4 (6/74)
Nematoda	16.4%	0.17	1.43	0.84	1.45	41.40
Oligochaeta	65.9	1.00	12.28	26.36	6.63	134.44
Polychaeta						
S. benedicti	8.8	0.13	2.63	14.61	0.04	5.02
Arthropoda						
B. improvisus	2.9	0	7.81	0	0	0
Mollusca						
M. arenaria	1.6	0.74	0.70	0.31	2.47	0.16
M. balthica	1.7	0.68	0.32	0.19	0	3.10
Total	97.3%	2.72	25.17	42.31	10.59	185.02
All organisms†	100.0	3.62	26.70	44.21	11.76	186.21

*Numerical percentage of all noncolonial organisms collected.

†All noncolonial organisms collected.

in September and December. The molluscs were dominated by two species of clams, Mya arenaria and Macoma balthica, which together accounted for 82.9% of the total mollusc count. During most of the sampling months, neither species was very abundant (Table 13), M. arenaria was most abundant in March 1974, and M. balthica was most abundant in June 1974.

Station CS-B

We collected a total of 48 taxa and 7,732 noncolonial specimens at Station CS-B. Seven of the taxa were colonial types. Table 14 presents the 48 taxa and the number of specimens collected during the five surveys.

Table 15 lists taxa comprising at least 1% of the total noncolonial specimen count. Together, the six most abundant taxa accounted for 96.6% of the noncolonial specimen count. In general, the abundant taxa were the same as at CS-A. The oligochaetes again were the most abundant group; however, at CS-B, they were most abundant in September 1973, whereas at CS-A, they were most abundant in June 1974.

We recovered fewer nematodes at CS-B than at CS-A. At CS-B, these animals were most numerous in September 1973 and in March and June 1974.

We encountered the same number of polychaete species (14) at both Carquinez Strait stations. Most were common to both stations, but Caulleriella hamata and Polydora caulleryi were found only at CS-A, and Asychis sp. and Mediomastus californiensis were found only at CS-B. None were abundant or common.

The sediment at CS-B was populated more densely with polychaetes than the sediment at CS-A. Although S. benedicti was again the most abundant polychaete, the increase in population concentration was not due to an increase in the number of that species but to a sudden appearance of a large number of another polychaete, Tharyx parvus, in September when 364 individuals were collected. This species accounted for 27.5% of the total polychaete count

Table 14

DISTRIBUTION AND ABUNDANCE OF SPECIES AT STATION CS-B

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY: SURVEY P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	SPECIMEN TOTAL
PROTOZOA						
FORAMINIFERA-UNIDENTIFIED SPP.	--	--	--	--	2	2
PORIFERA						
PORIFERA-UNIDENTIFIED SPP.	P	--	--	--	--	P
CNIDARIA						
CAMPANULARIA SP.	--	--	P	--	--	P
CNIDARIA-UNIDENTIFIED SPP.	--	--	--	P	--	P
HYDROZOA-UNIDENTIFIED SPP.	--	--	--	--	P	P
NEMERTEA						
NEMERTEA-UNIDENTIFIED SPP.	1	--	--	--	--	1
NEMATODA						
NEMATODA-UNIDENTIFIED SPP.	2	115	3	157	85	363
ANNELIDA-OLIGOCHAETA						
OLIGOCHAETA-UNIDENTIFIED SPP.	2	3435	192	1392	646	5667
ANNELIDA-POLYCHAETA						
ASYCHIS SP.	5	--	--	--	--	5
STREBLOSPIO BENEDICTI	8	661	30	69	6	774
HETEROMASTUS FILIFORMIS	1	1	1	1	--	4
NEANTHES SUCCINEA	1	--	2	2	--	5
EXOGONE LOUREI	--	2	--	--	--	2
POLYDORA LIGNI	--	1	--	--	4	5
THARYX PARVUS	--	364	--	--	--	364
GLYCINDE SP.	--	64	4	5	1	75
MEDIOMASTUS CALIFORNIENSIS	--	1	--	--	--	1
PSEUDOPOLYDORA KEMPI CALIFORNICA	--	1	--	--	--	1
ETEONE LIGHTI	--	--	10	3	6	19
CHAETOZONE SP.	--	--	2	--	--	2
THARYX SP.	--	--	--	1	--	1
ETEONE LONGA CALIFORNICA	--	--	--	--	1	1

Table 14 (Concluded)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY SURVEY P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	SPECIMEN TOTAL
ARTHROPODA						
COPEPODA-UNIDENTIFIED SPP.	2	1	--	--	7	10
CANCRIDAE-UNIDENTIFIED JUVENILE	1	--	--	--	--	1
PARAPHOXUS MILLERI	--	2	--	--	--	2
CAPRELLIDEA-UNIDENTIFIED SPP.	--	1	--	--	--	1
COROPHIUM INSIDIOSUM	--	1	--	--	--	1
AMPELISCA MILLERI	--	--	2	--	2	4
BALANUS SP., CF AMPHITRITE	--	--	2	--	--	2
BALANUS CARIOSUS	--	--	--	41	--	41
PYCNOGONIDA-UNIDENTIFIED SPP.	--	--	--	1	--	1
MYSIDACEA-UNIDENTIFIED SPP.	--	--	--	--	1	1
MOLLUSCA						
MYA ARENARIA	2	85	59	50	19	215
MUSCULUS SENHOUSIA	6	--	1	2	--	9
MYTILUS EDULIS	3	--	3	--	--	6
MACOMA BALTHICA	--	5	2	47	32	86
TAPES JAPONICA	--	1	--	1	1	3
ODOSTOMIA (MENESTHO) FETELLA	--	1	11	11	--	23
GEMMA GEMMA	--	--	5	--	--	5
NASSARIUS OBSOLETUS	--	--	8	--	--	8
ODOSTOMIA (EVALEA) SP. A	--	--	9	--	--	9
ODOSTOMIA (EVALEA) TENUISCULPTA	--	--	--	3	--	3
ODOSTOMIA (EVALEA) FRANCISCANA	--	--	--	1	--	1
ODOSTOMIA (EVALEA) SP., CF DELICIOSA	--	--	--	2	--	2
ECTOPROCTA						
MEMBRANIPORA PERFRAGILIS	P	P	P	--	P	P
CHEILOSTOMATA-UNIDENTIFIED SPP.	P	--	--	--	--	P
MEMBRANIPORA VILLOSA	--	--	--	--	P	P
ENIGMATICA						
ENIGMATICA	--	--	--	--	1	1
GRAND TOTALS						
SPECIMENS	54	4743	346	1745	414	[illegible]32
TAXA	15	14	20	19	14	43

Table 15

CONCENTRATIONS OF THE MOST ABUNDANT
BENTHIC ORGANISMS COLLECTED AT STATION CS-B
(Individuals per Liter)

	Percentage of Population*	Survey P (3/13)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)
Nematoda	4.7%	0.04	3.83	0.10	5.03	3.05
Oligochaeta	73.3	0.04	113.37	6.40	44.62	23.15
Polychaeta						
S. benedicti	10.0	0.16	21.82	1.00	2.21	0.22
T. parvus	4.7	0	12.01	0	0	0
Mollusca						
M. arenaria	2.8	0.04	2.80	1.97	1.60	0.68
M. balthica	1.1	0	0.16	0.07	1.51	1.15
Total	96.6%	0.28	153.99	9.54	54.97	28.25
All organisms†	100.0%	0.70	156.53	11.53	57.53	29.18

*Numerical percentage of all noncolonial organisms collected.

†All noncolonial organisms collected.

at CS-B. _T. parvus_ was not encountered during any other sampling month. Only four specimens of this species were found at CS-A.

Balanus improvisus was absent from the sediment samples collected at CS-B. Although 10 species of arthropods were collected there, the total number collected amounted to less than 1% of the total specimen count. The most abundant arthropod was another barnacle, _Balanus cariosus_, also found on a single rock, and collected only in March 1974.

Results and Discussion
Biological Characteristics
ALC

The percentage of molluscs in the population at CS-B was about the same as that at CS-A. All the species found at CS-A also were found at CS-B; however, the sediment at CS-B contained five additional species, including the minute clam Gemma gemma. Only five G. gemma were collected, and all were found in December. The other four species were snails of the genus Odostomia, which were encountered in small numbers and only in December 1973 and March 1974.

Although CS-B was located in the same general area as CS-A, the numerical fluctuations in the benthic population differed markedly between stations. In general, the benthic population at CS-A reached a peak in June 1974, but it peaked at CS-B in September 1973. At both stations, the numerical fluctuation in the benthic population was influenced strongly by changes in the number of nematodes and oligochaetes. The September peak observed at CS-B was enhanced by the appearance of relatively large numbers of the polychaetes S. benedicti and T. parvus. At CS-A, the size of the S. benedicti population did not peak until December, and insignificant numbers of T. parvus were found. At CS-A, the mollusc M. arenaria was most abundant in September 1973; however, at CS-B, it was most abundant in March 1974.

Alcatraz Disposal Site

The Alcatraz disposal site was unique: many of the animals collected were not found elsewhere, and the composition and size of the population fluctuated markedly. Nearly all the 133 species collected at ALC could be considered transient. Only the nematodes, oligochaetes, and the mollusc Adula diegensis were found in all four surveys. The nemerteans, three polychaetes (Hesionura sp., Mediomastus californiensis, Polydora caulleryi), a mollusc (Macoma nasuta), and two bryozoans (Scrupocellaria sp. and Hippothoa hyalina) were present in three surveys.

Ninety-eight species were found only once during the four surveys. The Alcatraz disposal area was inhabited by more species of bryozoans (Ectoprocta) than any other area studied. Table 16 summarizes the biological data obtained at ALC.

Table 16

DISTRIBUTION AND ABUNDANCE OF SPECIES AT STATION ALC

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY SURVEY P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	SPECIMEN TOTAL
PROTOZOA						
FORAMINIFERA-UNIDENTIFIED SPP.	--	--	4	--	1	5
PORIFERA						
KERATOSA-UNIDENTIFIED SPP.	--	P	--	--	--	P
DEMOSPONGIAE-UNIDENTIFIED SPP.	--	--	--	P	--	P
CNIDARIA						
HALIPLANELLA SP.	--	1	1	--	--	2
CALYPTOBLASTEA-UNIDENTIFIED SP. A	--	P	--	--	--	P
CALYPTOBLASTEA-UNIDENTIFIED SP. B	--	P	--	--	--	P
HYDROZOA-UNIDENTIFIED SPP.	--	P	--	--	P	P
DIADUMENE SP.	--	--	1	--	--	1
CAMPANULARIA SP.	--	--	P	--	--	P
PLATYHELMINTHES						
PLATYHELMINTHES-UNIDENTIFIED SPP.	--	2	1	--	--	3
NEMERTEA						
NEMERTEA-UNIDENTIFIED SPP.	--	222	25	--	20	267
NEMATODA						
NEMATODA-UNIDENTIFIED SPP.	--	496	67	2	56	621
ANNELIDA-OLIGOCHAETA						
OLIGOCHAETA-UNIDENTIFIED SPP.	--	141	42	1	17	201
ANNELIDA-POLYCHAETA						
GLYCERA OXYCEPHALA	3	--	--	--	--	3
GLYCINDE SP.	3	5	8	--	--	16
MICROPHTHALMUS SP.	--	29	--	--	--	29
SPIOPHANES BOMBYX	--	1	--	--	4	5
POLYCHAETA-UNIDENTIFIED SPP.	--	2	--	--	--	2
POLYDORA SOCIALIS	--	1	--	--	--	1
GLYCERA TENUIS	--	45	--	--	29	74

Results and Discussion
Biological Characteristics
ALC

Table 16 (Continued)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY SURVEY P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	SPECIMEN TOTAL
HAPLOSCOLOPLOS PUGETTENSIS	--	1	--	--	--	1
SCOLELEPSIS SQUAMATA	--	1	--	--	1	2
ARMANDIA BREVIS	--	31	13	--	--	44
ETEONE DILATAE	--	1	--	--	--	1
HESIONURA SP.	--	[illegible]	42	--	189	10500
SYLLIDES SP.	--	1265	1	--	--	1266
ARCHIANNELIDA-UNIDENTIFIED SPP.	--	1	--	--	--	1
MEDIOMASTUS CALIFORNIENSIS	--	27	11	--	1	39
PRIONOSPIO SP.	--	1	--	--	--	1
THARYX SP., CF MONILARI	--	1	--	--	--	1
POLYDORA CAULLERYI	--	1	64	--	2	67
EXOGONE LOUREI	--	1	14	--	--	15
ANAITIDES SP.	--	--	51	--	--	51
CAPITELLA CAPITATA	--	--	4	--	--	4
EUMIDA SP.	--	--	1	--	--	1
GLYCERA AMERICANA	--	--	1	--	--	1
COSSURA PYGODACTYLATA	--	--	1	--	--	1
ETEONE LONGA CALIFORNICA	--	--	1	--	--	1
STREBLOSPIO BENEDICTI	--	--	9	--	--	9
PECTINARIA CALIFORNIENSIS	--	--	1	--	--	1
ANAITIDES WILLIAMSI	--	--	93	--	1	94
GYPTIS BREVIPALPA	--	--	1	--	--	1
HETEROMASTUS FILIFORMIS	--	--	1	--	--	1
LUMBRINERIS SP.	--	--	1	--	--	1
PHYLLODOCIDAE-UNIDENTIFIED SPP.	--	--	1	--	--	1
NEAR EUMIDA SANGUINEA	--	--	1	--	--	1
SPIOPHANES SP.	--	--	1	--	--	1
NEREIS LATESCENS	--	--	1	--	--	1
EULALIA AVICULISETA	--	--	1	--	--	1
POLYCIRRUS CALIFORNICUS	--	--	1	--	--	1
PRIONOSPIO CIRRIFERA	--	--	3	--	--	3
CHONE MINUTA	--	--	1	--	--	1
THARYX SP.	--	--	3	--	--	3
PALEANOTUS BELLIS	--	--	1	--	--	1
STREPTOSYLLIS SP.	--	--	4	--	[illegible]	[illegible]
CHONE MOLLIS	--	--	1	--	--	1
LUMBRINERIS TETRAURA	--	--	4	--	--	4
NEANTHES SUCCINEA	--	--	3	--	--	3
NEPHTYS CALIFORNIENSIS	--	--	--	--	1	1

Table 1[illegible] (continued)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY					SPECIMEN TOTAL
	SURVEY					
	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	
ARTHROPODA						
PHOTIS BREVI[illegible]	--	1	141	--	--	142
COPEPODA-U[illegible]IFIED SPP.	--	1	8	--	--	9
MEL[illegible]A DENTATA	--	--	1	--	--	1
ISCH[illegible]ROCERUS [illegible]GUIPES	--	--	1	--	--	1
[illegible]OROPHIUM ACHERUSICUM	--	[illegible]	8	--	2	10
[illegible] PUGETTENSIS	--	[illegible]	26	--	--	26
[illegible] SP.	[illegible]	--	2	--	--	2
CA[illegible] A[illegible]	--	--	3	--	--	3
LE[illegible]	--	--	5	--	--	5
AMPEL[illegible]	--	[illegible]	[illegible]	[illegible]	2	29
[illegible]ACRURA[illegible] UNIDENTIFIED SPP.	--	[illegible]	3	--	--	3
GRA[illegible] [illegible]PONIC[illegible]	[illegible]	--	[illegible]	[illegible]	--	1
[illegible]NIDOTEA [illegible]	--		[illegible]	[illegible]	--	3
[illegible]ROTOMED[illegible]	--	--	[illegible]	[illegible]	--	2
STENOTH[illegible]	[illegible]	[illegible]	1	--	--	1
AMPHIPO[illegible]	--	[illegible]	3	--	--	3
AEGINE[illegible]	--	--	1	--	--	1
MELITA [illegible]	--		2	--	--	2
ASELLOTA-U[illegible]	[illegible]	--	1	--	--	1
TIRON BIOCELL[illegible]	[illegible]	--	5	--	--	5
PINNIAA FRANCISC[illegible]	[illegible]	--	1	--	--	1
DULICHIA SP.	--	--	1	--	--	1
PODOCERUS SP.	--	--	1	--	--	1
UPOGEBIA PUGETTENSIS	--	--	1	--	--	1
CAPRELLA SP.	--	--	2	--	--	2
DIASTYLOPSIS SP.	--	--	--	1	--	1
ISCHYROCERUS SP.	--	--	--	1	--	1
LIMNORIA QUADRIPUNCTATA	--	--	--	--	2	2
PARAPHOXUS MILLERI	--	--	--	--	1	1
PHOTIS SP.	--	--	--	--	1	1
MOLLUSCA						
MACOMA NASUTA	[illegible]	1	13	1	--	23
TELLINA MODESTA	--	3	--	--	2	5
TRANSENNELLA TANTILLA	--	115	8	--	--	126
MYTILUS EDULIS	--	1	3	--	--	4
ADULA DIEGENSIS	--	31	4	1	1	41
TAPES JAPONICA	--	1	--	--	--	1
MYSELLA FERRUGINOSA	--	17	--	--	--	17
HIATELLA ARCTICA	--	3	--	--	--	3

Table 16 (Concluded)

TAXA	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	SPECIMEN TOTAL
	TOTAL NUMBER OF SPECIMENS PER SURVEY					
		SURVEY				
MACOMA BALTHICA	--	3	2	--	--	5
FARTULUM SP.	--	9	--	--	--	9
ZIRFAEA PILSBRYI	--	--	92	--	--	92
ODOSTOMIA (EVALEA) FRANCISCANA	--	--	31	--	--	31
PROTOTHACA STAMINEA	--	--	4	--	--	4
PLATYODON CANCELLATUS	--	--	1	--	--	1
MACOMA INQUINATA	--	--	10	--	--	10
NASSARIUS MENDICUS	--	--	1	--	--	1
ECTOPROCTA						
CHEILOSTOMATA-UNIDENTIFIED SPP.	P	--	--	--	--	P
CELLARIA MANDIBULATA	P	--	--	--	--	P
SCRUPOCELLARIA SP.	P	P	P	--	P	P
TRICELLARIA OCCIDENTALIS	P	P	--	--	--	P
CHAPPERIA PALUTA	--	P	--	--	--	P
CRISIA MAXIMA	--	P	--	--	P	P
TRICELLARIA TERNATA	--	P	--	--	--	P
SCRUPOCELLARIA CALIFORNICA	--	P	--	--	--	P
HIPPOTHOA HYALINA	--	P	P	--	P	P
CALLOPORA SP.	--	P	--	--	--	P
CHEILOPORA PRAELONGA	--	P	--	--	--	P
SMITTOIDEA PROLIFICA	--	P	--	--	--	P
MICROPORELLA CALIFORNICA	--	P	--	--	--	P
ELECTRA ARCTICA	--	P	--	P	--	P
CELLARIA SP.	--	P	--	--	--	P
PARASMITTINA TRISPINOSA	--	P	--	--	--	P
HIPPOTHOA CORNUTA	--	P	--	--	--	P
LAGENIPORA PUNCTULATA	--	P	--	--	--	P
TEGELLA ARMIFERA	--	P	--	--	P	P
MEMBRANIPORA PERFRAGILIS	--	P	--	--	--	P
CRISIA OCCIDENTALIS	--	P	--	--	--	P
BUGULA SP.	--	--	P	--	--	P
FILICRISIA SP.	--	--	P	--	--	P
CONOPEUM RETICULUM	--	--	--	P	--	P
CALLOPORA ARMATA	--	--	--	--	P	P
TRICELLARIA SP.	--	--	--	--	P	P
SCHIZOPORELLA SP.	--	--	--	--	P	P
ENIGMATICA						
ENIGMATICA	--	--	6	--	--	6
GRAND TOTALS						
SPECIMENS	9	12764	888	7	1419	15087
TAXA	7	58	82	9	28	133

We collected a total of 15,078 noncolonial specimens during the study, most of them (84.6%) in September 1973. In contrast only seven specimens were found in the March 1974 samples. The December 1973 and June 1974 yields were 888 and 1,419, respectively. In terms of the four-survey total,* the most abundant taxa were the Nemertea, Nematoda, Oligochaeta, three polychaetes (*Hesionura* sp., *Syllides* sp., and *Streptosyllis* sp.), and one arthropod (*Photis brevipes*). We included *P. brevipes* in the abundant species list even though it constituted only 0.9% of the total specimen count. Table 17 presents the relative population densities and the abundant species.

The "population explosion" of September 1973 was almost entirely the result of the appearance of the polychaete *Hesionura* sp., an organism accounting for 457.7 of the 567.3 noncolonial specimens found per liter of sediment during that month. The numerical dominance of this species did not extend to subsequent sampling months, and, although *Hesionura* sp. accounted for 80.7% of the total September specimen count, it constituted only 1.4% of the noncolonial specimens collected in December, 13.3% in June 1974, and it was absent in March 1974.

The seasonal fluctuation in the number of nematodes, oligocheates, and the polychaete *Syllides* sp. essentially paralleled that of *Hesionura* sp. All these taxa were most numerous in September; in December, their numbers decreased considerably; and, in March 1974, only two nematodes and one oligochaete were found. *Syllides* sp. was absent in March 1974 and June 1974, a month when other abundant species increased. Although we collected a total of 1,090 specimens of *Streptosyllis* sp., we found none in September 1973 and March 1974 and only four in December 1973. This was the most abundant polychaete (1,086) species collected in June.

Photis brevipes was found only in September and December 1973 and was the most abundant organism collected in December. Of the 58 benthic species collected during September, 18 were

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*The Match 1973 results are not included because the sampling site was not located at the same part of the disposal site as that used in the rest of the study.

Table 17

CONCENTRATION OF THE MOST ABUNDANT BENTHIC ORGANISMS
COLLECTED AT STATION ALC
(Individuals per Liter)

	Percentage of Population*	Survey P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)
Nemertea	1.8%	0	9.87	1.07	0	0.82
Nematoda	4.1	0	22.04	2.86	0.07	2.30
Oligochaeta	1.3	0	6.27	1.79	0.03	0.70
Polychaeta						
Hesionura sp.	69.6	0	457.73	0.51	0	7.78
Syllides sp.	8.4	0	56.22	0.04	0	0
Streptosyllis sp.	7.2	0	0	0.17	0	44.69
Arthropoda						
P. brevipes	0.9	0	0.04	6.02	0	0
Total	93.3%	--	552.17	12.46	0.10	56.29
All organisms†	100.0	--	567.29	37.95	0.24	58.40

*Numerical percentage of all noncolonial organisms collected.

†All noncolonial organisms collected.

polychaetes, 2 were arthropods, 10 were molluscs, and 19 were bryozoans (Ectoprocta). As mentioned earlier, 84.6% of all noncolonial specimens found at ALC were collected during September 1973; and, of the 12,764 specimens collected, 80.7% were identified as the polychaete *Hesionura* sp.

Photis brevipes and the copepoda were the only types of arthropod found in September, each being represented by one specimen. Four of the 10 mollusc species were found only in September, Mysella ferruginosa being the most abundant.

The largest number of taxa (82), represented by only 888 specimens, was collected in December 1973. Fifty-six species were not found in samples collected during the other sampling months. Of these, 24 were polychaetes, the most diverse and abundant group of December 1973. The most numerous polychaete species collected in December were Polydora caulleryi, Anaitides williamsi, and Anaitides sp. other than A. williamsi. A. williamsi, with 93 specimens, was the most abundant. Together, these three species comprised 66.2% of the total polychaete specimen count in December. Hesionura, Syllides, and Streptosyllis--which were numerous in terms of the four-survey specimen count--were not abundant in December. A total of 17 specimens were taken; these constituted only 5% of the total number of polychaetes collected in December.

Thirty different arthropod species were collected at Station ALC, and 21 of them were found only in December. The 249 specimens collected in December accounted for 95.4% of the total number of arthropod specimens collected at ALC.

Eleven mollusc species, represented by 178 specimens, were collected in December. Two of the six species that were exclusive--namely, Zirfaea pilsbryi and Odostomia (Evalea) franciscana--were the most abundant molluscs collected in December.

In March 1974, the sediment collected from the Alcatraz disposal site was almost devoid of macrobenthic organisms. We collected nine species, three of them colonial types, one an unidentified species of Porifera, and the other two the bryozoans Electra arctica and Conopeum reticulum.

The generally abundant taxa were absent, except for the nematodes (two specimens) and oligochaetes (one specimen). The sediment samples averaged 9.6 liters and did not yield a single polychaete; Diastylopis sp. and Ischyrocerus sp. were the only arthropods present, and Macoma nasuta and Adula diegensis were

the only molluscs present. These four species each were represented by one specimen.

We collected 77 noncolonial taxa in December 1973 and only 20 in June; however, the specimen count in June was about 60% larger than in December. Nine of the taxa collected in June were polychaetes. Nephtys californiensis, a polychaete represented by a single specimen, was found at this station only in June, and Adula diegensis (one specimen) and Tellina modesta (two specimens) were the only molluscs represented. We collected seven types of bryozoans, three of which--Collopora armata, Tricellaria sp., and Schizoporella sp.--were found only in June.

Oakland Inner Harbor

Station OIH was the most densely populated of all stations surveyed during this study. The average number of organisms per liter of sediment was 867.5. A total of 131,256 specimens were collected during the five surveys. Organism types were diverse, and the number of identified taxa (137) was only one less than that at Station HP (Hunters Point), the site of the greatest number of species. OIH also was inhabited by 23 year-round species--more than at any other station. Table 18 presents the total number of each species found at this station.

Although 137 taxa were found at this station, only six were abundant, as shown in Table 19. As at most of the other stations, large numbers of nematodes and oligochaetes were collected, but the most abundant species was the polychaete Streblospio benedicti. Other species accounting for at least 0.9% of the total noncolonial specimen count at OIH were the polychaetes Exogone lourei and Pseudopolydora paucibranchiata and the mollusc Gemma gemma. The number of specimens representing these six taxa constituted 94.3% of the total noncolonial specimen count.

In March 1973, we collected 21,153 noncolonial specimens. In September, 36.1% more were collected. Numerically, the benthic population reached a peak in December, when 41,772 noncolonial individuals were recovered from the sediment samples. In March

Table 18

DISTRIBUTION AND ABUNDANCE OF SPECIES AT STATION OIH

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY — SURVEY P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	SPECIMEN TOTAL
PROTOZOA						
FORAMINIFERA-UNIDENTIFIED SPP.	--	--	14	2	--	16
PORIFERA						
KERATOSA-UNIDENTIFIED SPP.	P	P	--	--	--	P
DEMOSPONGIAE-UNIDENTIFIED SPP.	--	--	--	P	--	P
CNIDARIA						
PENNATULACEA-UNIDENTIFIED SPP.	2	4	--	--	--	6
DIADUMENE SP.	1	--	--	--	--	1
CALYPTOBLASTEA-UNIDENTIFIED SPP.	P	--	--	--	--	P
CNIDARIA-UNIDENTIFIED SPP.	P	P	--	--	--	P
STYLATULA ELONGATA	--	--	40	5	1	46
HYDROZOA-UNIDENTIFIED SPP.	--	--	P	P	--	P
CAMPANULARIA SP.	--	--	--	P	--	P
HALIPLANELLA SP.	--	--	--	1	--	1
PLUMULARIA SP.	--	--	--	--	P	P
NEMERTEA						
NEMERTEA-UNIDENTIFIED SPP.	24	12	26	44	13	119
NEMATODA						
NEMATODA-UNIDENTIFIED SPP.	306	690	1347	2230	1592	6165
ANNELIDA-OLIGOCHAETA						
OLIGOCHAETA-UNIDENTIFIED SPP.	4886	9396	12244	13084	2136	41746
ANNELIDA-POLYCHAETA						
HETEROMASTUS FILIFORMIS	3	--	3	--	2	8
MEDIOMASTUS CALIFORNIENSIS	12	--	5	1	1	19
HAPLOSCOLOPLOS POGETTENSIS	35	23	17	23	--	98
PECTINARIA CALIFORNIENSIS	34	20	32	23	3	112
POLYDORA LIGNI	4	99	24	1	3	131
PSEUDOPOLYDORA PAUCIBRANCHIATA	64	376	785	6	--	1231
SCOLELEPSIS SQUAMATA	36	2	5	4	8	55

Table 18 (Continued)

TAXA	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	SPECIMEN TOTAL
	TOTAL NUMBER OF SPECIMENS PER SURVEY — SURVEY					
STREBLOSPIO BENEDICTI	10715	12617	21296	14124	577	59331
GLYCERA AMERICANA	2	--	--	1	--	3
GLYCINDE SP.	51	65	67	17	2	202
NEPHTYS CAECOIDES	54	24	37	5	4	129
PHOLOE MINUTA	23	13	15	14	6	71
EXOGONE LOUREI	1971	496	1102	467	325	4361
SPHAEROSYLLIS SP.	192	99	398	215	15	919
PSEUDOPOLYDORA KEMPI CALIFORNICA	30	10	10	--	--	50
NEPHTYS CORNUTA FRANCISCANA	31	14	35	15	6	101
NEPHTYS PARVA	1	14	4	2	--	21
ETEONE LONGA CALIFORNICA	17	62	34	10	1	124
CAPITELLA CAPITATA	12	2	5	7	7	33
THARYX SP.	2	--	2	--	--	4
MYRIOCHELE SP., NEAR GRACILIS	2	--	--	--	--	2
TROCHOCHAETA MULTISETOSUM	5	1	--	2	2	10
CIRRATULUS CIRRATUS	5	--	2	--	1	8
THARYX PARVUS	5	2	1	1	--	9
SCHISTOMERINGOS LONGICORNIS	6	7	2	13	6	36
GLYCERA SP., NEAR ROBUSTA	1	--	--	--	--	1
ETEONE DILATAE	1	1	--	3	--	5
HARMOTHOE IMBRICATA	1	3	3	--	3	10
CHAETOZONE SP.	1	--	3	--	--	4
ASYCHIS SP.	1	6	2	5	--	14
HARMOTHOE SP., CF IMBRICATA	1	--	--	--	--	1
PHYLLODOCIDAE-UNIDENTIFIED SPP.	1	--	--	--	--	1
POLYDORA SOCIALIS	3	--	--	--	--	3
MEDIOMASTUS CALIFORNIENSIS - JUVENILE	1	--	--	--	--	1
HARMOTHOE SP.	--	9	2	--	--	
ETEONE LIGHTI	--	10	7	8	61	86
EUCHONE LIMNICOLA	--	16	23	--	--	39
ARMANDIA BREVIS	--	1	1	2	--	4
COSSURA PYGODACTYLATA	--	7	1	1	3	12
PROMYSTIDES SP.	--	1	--	--	--	1
PRIONOSPIO SP.	--	3	--	--	--	3
ANAITIDES SP.	--	--	1	--	--	1
CHONE GRACILIS	--	--	2	--	--	2
MELINNAMPHARETE GRACILIS	--	--	1	--	--	1
EUMIDA BIFOLIATA	--	--	1	--	--	1
SCHISTOMERINGOS SP. - JUVENILE	--	--	2	--	--	2
GYPTIS BREVIPALPA	--	--	--	2	1	3

Table 18 (Continued)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY — SURVEY P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	SPECIMEN TOTAL
NEANTHES SP.	--	--	--	1	--	1
CAPITELLA SP.	--	--	--	10	--	10
HESIONELLA MCCULLOCHAE	--	--	--	4	--	4
SPIOPHANES SP.	--	--	--	1	--	1
POLYDORA CAULLERYI	--	--	--	1	--	1
TEREBELLIDAE-UNIDENTIFIED SPP.	--	--	--	1	--	1
PRIONOSPIO CIRRIFERA	--	--	--	1	--	1
SPIOPHANES MISSIONENSIS	--	--	--	--	1	1
SIPUNCULA						
SIPUNCULA-UNIDENTIFIED SPP.	--	--	--	29	--	29
ARTHROPODA						
OSTRACODA-UNIDENTIFIED SPP.	234	310	--	--	--	544
CUMACEA-UNIDENTIFIED SP. A	13	--	--	--	--	13
CUMACEA-UNIDENTIFIED SP. B	8	--	--	--	--	8
AMPELISCA MILLERI	32	532	78	6	14	662
LEPTOCHELIA DUBIA	8	11	3	4	--	26
CRANGON SP.	1	--	--	--	--	1
AMPHIPODA-UNIDENTIFIED SPP.	1	3	--	--	--	4
PHOTIS CALIFORNICA	1	--	--	--	--	1
PINNIXA FRANCISCANA	2	15	4	8	2	31
LECYTHORHYNCHUS MARGINATUS	2	--	--	--	--	2
CUMACEA-UNIDENTIFIED SPP.	3	--	--	--	--	3
PYROMAIA TUBERCULATA	1	--	--	--	--	1
EUDORELLA PACIFICA	2	--	--	--	--	2
BRACHYURA-UNIDENTIFIED SPP.	1	--	--	--	--	1
SARSIELLA ZOSTERICOLA	--	1	564	458	18	1041
EUDORELLA SP.	--	6	--	5	2	13
CUMELLA VULGARIS	--	302	128	331	65	826
ANTHURIDAE-UNIDENTIFIED SPP.	--	2	--	--	--	2
COPEPODA-UNIDENTIFIED SPP.	--	6	2	9	18	35
PHOTIS BREVIPES	--	3	--	--	--	3
COROPHIUM ACHERUSICUM	--	4	--	--	10	14
GRANDIDIERELLA JAPONICA	--	9	15	--	--	24
GAMMARIDAE-UNIDENTIFIED SPP.	--	1	--	--	--	1
SARSIELLA SP.	--	1	--	--	--	1
DECAPODA-UNIDENTIFIED SPP.	--	1	5	--	--	6
PHOTIS SP.	--	--	58	--	--	58
SYNIDOTEA LATICAUDA	--	--	3	--	--	3

Table 18 (Continued)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY: SURVEY P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	SPECIMEN TOTAL
BALANUS CRENATUS	--	--	2	--	--	2
PYCNOGONIDA-UNIDENTIFIED SPP.	--	--	1	1	1	3
ARACHNIDA-UNIDENTIFIED SPP.	--	--	--	1	--	1
INSECTA-UNIDENTIFIED SPP.	--	--	--	1	--	1
CALLIANASSA CALIFORNIENSIS	--	--	--	--	1	1
MOLLUSCA						
MACOMA ACOLASTA	1	7	2	--	--	10
MACOMA INQUINATA	3	6	3	1	14	27
MACOMA NASUTA	138	201	112	99	86	636
TELLINA MODESTA	2	--	2	--	1	5
TAPES JAPONICA	2	1	--	--	--	3
GEMMA GEMMA	2075	2908	2947	2913	204	11047
TRANSENNELLA TANTILLA	12	1	--	8	--	21
MYSELLA FERRUGINOSA	11	2	7	3	5	28
MUSCULUS SENHOUSIA	45	1	3	4	1	54
SILIQUA PATULA	1	--	--	--	--	1
MACOMA BALTHICA - JUVENILE	2	--	--	--	--	2
SILIQUA SLOATI	2	--	--	--	--	2
ADULA DIEGENSIS	1	--	--	--	--	1
MYTILUS EDULIS	3	--	3	8	4	18
PELECYPODA-UNIDENTIFIED SPP.	1	--	--	--	--	1
ODOSTOMIA (EVALEA) TENUISCULPTA	1	--	--	--	--	1
LYONSIA CALIFORNICA	--	2	--	--	--	2
ECTOPROCTA						
HIPPOTHOA HYALINA	P	--	--	--	--	P
MEMBRANIPORA PERFRAGILIS	P	--	--	--	--	P
FILICRISIA GENICULATA	P	--	--	--	--	P
BUGULA NERITINA	--	P	P	P	--	P
BUGULA CALIFORNICA	--	P	--	--	--	P
TRICELLARIA TERNATA	--	P	--	--	--	P
BUGULA SP.	--	P	--	--	--	P
TRICELLARIA SP.	--	--	P	--	--	P
CRYPTOSULA PALLASIANA	--	--	P	--	P	P
CRISIA MAXIMA	--	--	P	--	--	P
FILICRISIA SP.	--	--	P	--	--	P
ALCYONIDIUM PARASITICUM	--	--	--	P	--	P
CONOPEUM RETICULUM	--	--	--	P	--	P

Table 18 (Concluded)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY					SPECIMEN TOTAL
	SURVEY					
	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	
ECHINODERMATA						
HOLOTHUROIDEA-UNIDENTIFIED SPP.	--	341	223	65	--	679
CF LEPTOSYNAPTA SP.	--	1	--	--	--	1
CHORDATA						
CIONA INTESTINALIS	--	--	2	--	--	2
ENIGMATICA						
ENIGMATICA	2	--	4	--	--	6
GRAND TOTALS						
SPECIMENS	21153	28784	41772	34311	5236	131256
TAXA	76	66	69	64	44	137

Table 19

CONCENTRATIONS OF THE MOST ABUNDANT BENTHIC ORGANISMS COLLECTED AT STATION OIH
(Individuals per Liter)

	Percentage of Population*	Survey P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)
Nematoda	4.7%	8.27	20.35	54.10	89.56	52.03
Oligochaeta	31.8	132.05	277.17	491.73	525.46	69.80
Polychaeta						
S. benedicti	45.2	289.59	372.18	855.26	567.23	18.92
E. lourei	3.3	53.27	14.63	44.26	18.76	10.62
P. paucibranchiata	0.9	1.73	11.09	31.53	0.24	0
Mollusca						
G. gemma	8.4	56.08	85.78	118.35	116.99	6.67
Total	94.3%	540.99	781.20	1,595.23	1,318.24	158.04
All organisms†	100.0	571.70	849.08	1,677.59	1,377.95	171.11

*Numerical percentage of all noncolonial organisms collected.

†All noncolonial organisms collected.

1974, the size of the population declined markedly, and this decline continued in June when only 5,236 noncolonial specimens were collected.

In all sampling periods except for June 1974, the polychaetes were the most diverse and abundant group, contributing 55 species to the total. Nine percent of the total noncolonial specimen count was molluscs, of which we collected 17 species. Although we collected 32 species of arthropods, only 2.5% of the total number of noncolonial animals collected belonged to this group.

In March 1973, the polychaetes numbered 34 species, represented by 13,323 individuals or about 360/liter. Six of these species were not encountered in subsequent sampling periods. As indicated in Table 19, S. benedicti and E. lourei not only were the most abundant of all species collected in March 1973, but they also were the most abundant of all polychaete species for all five surveys.

Fewer polychaete species (29) were encountered in September; two species, represented by a total of four specimens, were found only during that month. S. benedicti, E. lourei, and Pseudopolydora paucibranchiata were the most abundant species, accounting for 96.4% of the polychaete count of 13,999 specimens (412.9/liter) in September. In December, we encountered 35 species of polychaetes, represented by 23,930 individuals (or about 961/liter)--the highest polychaete concentration encountered at OIH. The most abundant polychaete species were S. benedicti, E. lourei, and P. paucibranchiata. S. benedicti accounted for 855.3/liter. Five of the species collected in December were not found during the other sampling months.

Thirty-three species of polychaete were collected in March 1974, all but six appearing also during at least one of the other surveys. The most abundant species were S. benedicti (by far the most numerous--about 567 of the 602.0 polychaetes per liter of sediment), E. lourei, and Sphaerosyllis sp. Only six specimens of P. paucibranchiata were collected.

In June, we observed a marked decline in the size of the benthic population at OIH. The polychaetes were affected more than any other group. Fewer species (22) were present, and,

although S. benedicti was still the most abundant polychaete, it was not the most abundant species. P. paucibranchiata, which declined considerably in number in March 1974, was absent in June, and the number of E. lourei decreased slightly. In June, Spiophanes missionensis appeared for the first time and was represented by one specimen.

As mentioned earlier, we collected 32 arthropod taxa from OIH during the study. The most abundant group was the Ostracoda. Representatives of this group comprised about 47% of the total number of arthropod specimens collected at this station during the study. Only after the September 1973 sampling period did we develop the capability to identify the ostracods to the specific level and, upon identifying those collected in subsequent surveys, found that they were Sarsiella zostericola. The relatively large number of unidentified ostracods collected in March and September 1973 possibly were this species (see Table 18).

The mollusc community was composed primarily of the clam Gemma gemma (93.2% of the 11,859 mollusc specimens collected belonged to this species). The number of individuals increased from about 56/liter in March 1973 to about 118/liter in December 1973. The population density in March 1974 did not change, but as happened with other species, the concentration declined markedly in June 1974.

Macoma nasuta was another relatively abundant and common mollusc, as were Macoma inquinata, Mysella ferruginosa, and Musculus senhousia.

Hunters Point Disposal Site

We found 138 different kinds of benthic animals in the sediment samples collected at the Hunters Point disposal site. Table 20 lists the animals and their abundance. Fifty-eight of the specimens were polychaetes, 28 were arthropods, 20 were molluscs, 11 were bryozoans (Ectoprocta), and 24 belonged to other groups such as the Protozoa, Porifera, Nematoda, Cnidaria, Nemertea, Oligochaeta, Sipuncula, Echinodermata, Phoronida, and Chordata; one specimen could not be placed in any known taxonomic category.

Table 20

DISTRIBUTION AND ABUNDANCE OF SPECIES AT STATION HP

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY					SPECIMEN TOTAL
	SURVEY					
	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	
PROTOZOA						
FORAMINIFERA-UNIDENTIFIED SPP.	--	--	1	--	--	1
PORIFERA						
PORIFERA-UNIDENTIFIED SPP.	--	--	--	--	P	P
CNIDARIA						
DIADUMENE SP.	32	4	74	--	--	110
HALIPLANELLA SP.	32	22	23	19	20	116
HYDROZOA-UNIDENTIFIED SPP.	P	--	--	--	--	P
GONOTHYRAEA SP.	P	P	--	--	--	P
CALYPTOBLASTEA-UNIDENTIFIED SPP.	P	--	--	--	--	P
CAMPANULARIA SP.	--	--	P	P	P	P
BIMERIA SP.	--	--	--	--	P	P
NEMERTEA						
NEMERTEA-UNIDENTIFIED SPP.	47	40	48	32	43	210
NEMATODA						
NEMATODA-UNIDENTIFIED SPP.	13	109	80	21	51	274
ANNELIDA-OLIGOCHAETA						
OLIGOCHAETA-UNIDENTIFIED SPP.	14	61	141	29	41	286
ANNELIDA-POLYCHAETA						
CAPITELLIDAE-UNIDENTIFIED SPP.	1	--	--	--	1	2
MEDIOMASTUS CALIFORNIENSIS	279	241	662	276	404	1862
THARYX PARVUS	8	30	55	--	21	114
ASYCHIS SP.	15	19	31	52	30	147
POLYDORA SOCIALIS	5	--	--	--	--	5
STREBLOSPIO BENEDICTI	13	51	9	14	3	90
SCHISTOMERINGOS LONGICORNIS	3	2	3	5	6	19
NEPHTYS CORNUTA FRANCISCANA	3	2	10	15	93	123
EXOGONE LOUREI	1404	754	547	200	756	3661
POLYCHAETA-UNIDENTIFIED JUVENILE	3	--	--	--	--	3

Table 2J (Continued)

TAXA	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	SPECIMEN TOTAL
	TOTAL NUMBER OF SPECIMENS PER SURVEY — SURVEY					
CAPITELLA CAPITATA	15	14	2	2	3	36
CIRRATULUS CIRRATUS	10	6	7	5	41	69
COSSURA PYGODACTYLATA	5	2	4	1	3	15
LANGERHANSIA SP.	1	--	--	--	--	1
THARYX SP.	2	--	--	24	9	35
SPHAEROSYLLIS SP.	2	8	9	14	20	53
GLYCERA AMERICANA	1	3	--	--	--	4
ANAITIDES WILLIAMSI	1	--	--	--	--	1
HETEROMASTUS FILIFORMIS	3	4	--	--	--	7
ARMANDIA BREVIS	1	6	19	5	1	32
GYPTIS BREVIPALPA	1	--	--	1	1	3
BOCCARDIA TRUNCATA	--	1	--	--	--	1
POLYDORA SP.	--	4	3	--	--	7
ETEONE LONGA CALIFORNICA	--	1	1	3	4	9
GLYCERA SP.	--	1	--	1	8	10
NEPHTYS CAECOIDES	--	1	--	--	--	1
NEPHTYS PARVA	--	1	--	--	--	1
PHOLOE MINUTA	--	1	1	2	1	5
HARMOTHOE IMBRICATA	--	2	--	--	--	2
POLYDORA SOCIALIS	--	3	11	5	2	21
GLYCINDE SP.	--	7	3	2	27	41
SPIOPHANES FIMBRIATA	--	1	1	--	--	2
POLYDORA SOCIALIS	--	1	--	--	--	1
CAPITITA AMBISETA	--	--	1	--	--	1
EXOGONE SP.	--	--	1	--	--	1
AUTOLYTUS SP.	--	--	1	--	5	6
PSEUDOPOLYDORA PAUCIBRANCHIATA	--	--	1	--	--	1
POLYNOIDAE-UNIDENTIFIED SPP.	--	--	1	--	--	1
TROCHOCHAETA MULTISETOSUM	--	--	2	2	6	10
CHAETOZONE SP.	--	--	1	--	--	1
HAPLOSCOLOPLOS PUGETTENSIS	--	--	1	--	1	2
PRIONOSPIO CIRRIFERA	--	--	2	--	--	2
ETEONE DILATAE	--	--	2	--	--	2
POLYDORA LIGNI	--	--	--	2	52	54
GLYCERA OXYCEPHALA	--	--	--	1	--	1
OPHIODROMUS PUGETTENSIS	--	--	--	1	--	1
NOTOMASTUS (CLISTOMASTUS) TENUIS	--	--	--	5	--	5
SPIOPHANES MISSIONENSIS	--	--	--	3	2	5
PILARGIS SP.	--	--	--	1	--	1
POLYDORA CAULLERYI	--	--	--	15	25	40

Table 20 (Continued)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY — SURVEY P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	SPECIMEN TOTAL
STHENELANELLA UNIFORMIS	--	--	--	1	--	1
ANAITIDES SP.	--	--	--	--	1	1
PALEANOTUS BELLIS	--	--	--	--	1	1
PRIONOSPIO SP.	--	--	--	--	1	1
NEAR AMPHIDURUS PACIFICUS	--	--	--	--	1	1
TYPOSYLLIS SP.	--	--	--	--	1	1
SABELLIDAE-UNIDENTIFIED SPP.	--	--	--	--	1	1
SABELLARIA SP.	--	--	--	--	1	1
SIPUNCULA						
SIPUNCULA-UNIDENTIFIED SPP.	1	1	-	2	1	5
SIPUNCULUS SP.	--	--	--	--	2	2
ARTHROPODA						
COROPHIUM SP.	1	2	--	5	--	8
AMPELISCA MILLERI	1094	8635	42	37	437	10445
LEPTOCHELIA DUBIA	51	239	63	7	27	387
PYROMAIA TUBERCULATA	15	1	1	1	1	19
OSTRACODA-UNIDENTIFIED SPP.	1	4	--	--	--	5
UPOGEBIA SP.	1	--	--	--	--	1
CUMACEA-UNIDENTIFIED SP. B	1	--	--	--	--	1
EUDORELLA PACIFICA	1	--	--	--	--	1
SARSIELLA ZOSTERICOLA	--	5	52	12	60	129
COROPHIUM ACHERUSICUM	--	10	1	--	272	283
COROPHIUM INSIDIOSUM	--	7	--	--	--	7
BALANUS CRENATUS	--	--	7	--	--	7
PHOTIS SP.	--	--	1	1	--	2
ACARINA-UNIDENTIFIED SPP.	--	--	1	--	42	43
UPOGEBIA PUGETTENSIS	--	--	--	1	--	1
PHOTIS SP., CF BREVIPES	--	--	--	1	--	1
EUDORELLA SP.	--	--	--	--	14	14
PROTOMEDEIA SP.	--	--	--	--	1	1
PARAPLEUSTES PUGETTENSIS	--	--	--	--	3	3
DECAPODA-UNIDENTIFIED SPP.	--	--	--	--	1	1
COPEPODA-UNIDENTIFIED SPP.	--	--	--	--	4	4
CUMELLA VULGARIS	--	--	--	--	2	2
PARAPLEUSTES SP.	--	--	--	--	4	4
ANOMURA-UNIDENTIFIED LARVA	--	--	--	--	1	1
RHITHROPANOPEUS HARRISII	--	--	--	--	1	1
CANCER JORDANI	--	--	--	--	1	1

Table 20 (Continued)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY					SPECIMEN TOTAL
	SURVEY					
	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	
CAPRELLIDEA-UNIDENTIFIED SPP.	--	--	--	--	2	2
PYCNOGONIDA-UNIDENTIFIED SPP.	--	--	--	--	1	1
MOLLUSCA						
GEMMA GEMMA	4	--	1	4	2	11
TRANSENNELLA TANTILLA	12	1	--	--	3	16
MUSCULUS SENHOUSIA	5	1	1	1	2	10
MACOMA ACOLASTA	1	--	--	--	--	1
ADULA DIEGENSIS	1	1	--	--	--	2
MYA ARENARIA	2	--	--	--	1	3
MYSELLA FERRUGINOSA	1	--	2	1	1	5
PETRICOLA SP., CF CARDITOIDES	--	1	--	--	--	1
LYONSIA CALIFORNICA	--	1	--	--	--	1
MACOMA NASUTA	--	1	--	4	--	5
MACOMA BALTHICA	--	--	1	5	2	8
PODODESMUS SP. - JUVENILE	--	--	1	--	--	1
MYTILUS EDULIS	--	--	1	--	11	12
ALVINIA COMPACTA	--	--	3	--	--	3
PROTOTHACA STAMINEA	--	--	1	--	--	1
TAPES JAPONICA	--	--	1	--	1	2
MACOMA INQUINATA	--	--	1	--	3	4
OSTREA LURIDA	--	--	--	--	1	1
MODIOLUS SP.	--	--	--	--	1	1
HIATELLA ARCTICA	--	--	--	--	1	1
ECTOPROCTA						
BOWERBANKIA GRACILIS	P	--	--	--	--	P
CYCLOSTOMATA-UNIDENTIFIED SPP.	P	--	--	--	--	P
SCRUPOCELLARIA SP.	P	--	--	--	--	P
BUGULA SP.	P	--	--	--	--	P
HIPPOTHOA HYALINA	--	--	P	--	P	P
SMITTOIDEA PROLIFICA	--	--	P	--	P	P
ELECTRA ARCTICA	--	--	P	--	--	P
ALCYONIDIUM PARASITICUM	--	--	P	--	--	P
SMITTINA PROLIFICA	--	--	P	--	--	P
ANASCA-UNIDENTIFIED SPP.	--	--	P	--	--	P
BARENTSIA SP.	--	--	--	--	P	P
ENTOPROCTA						
BARENTSIA SP.	--	--	--	--	P	P
ECHINODERMATA						
HOLOTHUROIDEA-UNIDENTIFIED SPP.	4	1	--	--	1	6

Table 20 (Concluded)

TAXA	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	SPECIMEN TOTAL
	TOTAL NUMBER OF SPECIMENS PER SURVEY — SURVEY					
OPHIONEREIS SP.	--	--	--	--	1	1
PHORONIDA						
PHORONIS SP.	1	1	2	--	1	5
PHORONOPSIS VIRIDIS	--	--	3	--	--	3
PHORONIDA-UNIDENTIFIED SPP.	--	--	--	--	1	1
CHORDATA						
TUNICATA-UNIDENTIFIED SPP.	--	P	--	--	--	P
ENIGMATICA						
ENIGMATICA	--	--	1	--	2	3
GRAND TOTALS						
SPECIMENS	3111	10514	1945	841	2601	19012
TAXA	51	50	61	46	30	137

Results and Discussion
Biological Characteristics
HP

These animals were most abundant in September. During that month, we recovered individuals at an average of about 337/liter of sediment, as shown in Table 21. About 60/liter were removed from sediment collected in March 1973; however, only about 28/liter were found in sediment collected in March 1974, the month the fewest numbers of species and specimens were collected. In December 1973 and June 1974, the average numbers of organisms per liter were 67 and 90, respectively.

Table 21 lists each taxon that constituted at least 1% of the total number of noncolonial organisms obtained at HP and the average concentration of each specimen per liter. Only eight of the taxa met the 1% criteria of abundance. Listed in order of decreasing abundance, these were Ampelisca milleri (Arthropoda), Exogone lourei (Polychaeta), Mediomastus californiensis (Polychaeta), Leptochelia dubia (Arthropoda), Oligochaeta, Corophium acherusicum (Arthropoda), Nematoda, and Nemertea. Together, these taxa constituted 91.4% of the total noncolonial specimen count for HP.

The arthropods were the most abundant group at HP, their numerical dominance being attributable primarily to one species--Ampelisca milleri. This amphipod accounted for 91.8% of the total number of arthropods collected and about 55% of the total noncolonial specimen count. The high concentration of benthic organisms in September resulted from the appearance of large numbers of this amphipod that accounted for about 84% of the total number of noncolonial specimens collected. (The numbers of A. milleri collected during the other sampling months were not outstanding.)

Totaling 2.0% of the benthic population, Leptochelia dubia was not particularly abundant except in September 1973. Corophium acherusicum was absent in March of 1973 and 1974; but in June, this amphipod was quite abundant (272 specimens, 9.4/liter).

The most diverse group encountered was Polychaeta, of which we collected 58 species. Numerically, the polychaete population constituted about 34% of the total noncolonial organism count. Eleven of the species appeared in each survey period, but only Exogone lourei and Mediomastus californiensis appeared in significant numbers, the two making up 84.6% of the total number of polychaetes collected.

Table 21

CONCENTRATIONS OF THE MOST ABUNDANT BENTHIC ORGANISMS
COLLECTED AT STATION HP
(Individuals per Liter)

	Percentage of Population*	Survey P (3/73)	Survey 1 (9/73)	Survey 2 (12/73)	Survey 3 (3/74)	Survey 4 (6/74)
Nemertea	1.1%	0.91	1.28	1.65	1.08	1.49
Nematoda	1.4	0.25	3.49	2.75	0.71	1.77
Oligochaeta	1.5	0.27	1.96	4.84	0.97	1.43
Polychaeta						
E. lourei	19.2	27.26	24.17	18.80	6.73	26.25
M. californiensis	9.8	5.42	7.72	22.75	9.29	14.03
Arthropoda						
A. milleri	54.9	21.24	283.17	1.44	1.24	15.17
L. dubia	2.0	0.99	7.66	2.16	0.24	0.94
C. acherusicum	1.5	0	0.32	0.03	0	9.44
Total	91.4%	56.34	329.77	54.42	20.26	70.52
All organisms†	100.0	60.40	336.99	66.84	28.32	90.31

*Numerical percentage of all noncolonial organisms collected.

†All noncolonial organisms collected.

Results and Discussion
Biological Characteristics
SB-A

We recovered similar numbers of *E. lourei* per liter of sediment in March 1973, September 1973, and June 1974. Their concentration during these months fell in the range of 24 to 27/liter. A slight decrease in concentration was observed in December; and, in March 1974, the *E. lourei* population fell off markedly to about 7/liter.

The density of the *Mediomastus californiensis* population increased from about 5.4/liter in March 1973 to a peak of about 23/liter in December 1973, decreased by about 59% in March 1974, and increased to 61.6% of peak size in June 1974.

The nemerteans, nematodes, and oligochaetes were present during all sampling months, but none were particularly abundant in any of the surveys.

South Bay Disposal Sites

Station SB-A

As shown in Table 22, we collected a total of 91 taxa and 32,646 noncolonial specimens from Station SB-A between March 1973 and June 1974. The collection included 31 polychaetes, 17 arthropods, 16 molluscs, 10 bryozoans, and 7 cnidarians. Ninety-five percent of the 32,646 noncolonial specimens belonged to 14 of the 91 taxa. The 14 taxa are listed in Table 23.

Aquatic disposal of dredged sediment can be detrimental to benthic organisms in the disposal area, but we found no evidence of adverse effects at SB-A where disposal of dredged material occurred after the first census in March 1973. However, about seven months had passed from the time of disposal to the time of population censusing, a lapse of time probably sufficient to obscure any immediate effects. In addition, March 1973 appears to have been a poor reference period, because the sediment in the southern portion of the bay was not as well populated then as during the other sampling months.

Table 22

DISTRIBUTION AND ABUNDANCE OF SPECIES AT STATION SB-A

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY					SPECIMEN TOTAL
	SURVEY					
	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	
PROTOZOA						
FORAMINIFERA-UNIDENTIFIED SPP.	--	--	13	2	--	15
CNIDARIA						
GONOTHYRAEA SP.	P	P	--	--	--	P
DIADUMENE SP.	3	--	3	3	--	9
HALIPLANELLA SP.	3	1	19	52	--	75
CALYPTOBLASTEA-UNIDENTIFIED SPP.	P	P	--	--	--	P
CNIDARIA-UNIDENTIFIED SPP.	P	1	--	--	--	0
CAMPANULARIA SP.	--	--	P	P	P	P
SERTULARIA SP.	--	--	--	--	P	P
NEMERTEA						
NEMERTEA-UNIDENTIFIED SPP.	22	--	6	4	--	32
NEMATODA						
NEMATODA-UNIDENTIFIED SPP.	275	22	1974	448	116	2835
ANNELIDA-OLIGOCHAETA						
OLIGOCHAETA-UNIDENTIFIED SPP.	132	357	4041	1147	1293	6970
ANNELIDA-POLYCHAETA						
PSEUDOPOLYDORA PAUCIBRANCHIATA	2	1	1	8	--	12
POLYNOIDAE-UNIDENTIFIED SPP.	1	7	--	6	--	9
HETEROMASTUS FILIFORMIS	159	58	164	235	257	873
MEDIOMASTUS CALIFORNIENSIS	11	9	--	--	--	23
COSSURA PYGODACTYLATA	30	5	24	8	2	69
ASYCHIS SP.	20	35	3	16	17	91
POLYDORA CAULLERYI	20	397	35	112	23	589
POLYDORA SOCIALIS	1	--	--	--	--	1
EXOGONE LOURE I	228	1357	918	1557	243	4379
SPHAEROSYLLIS SP.	1	68	144	486	22	721
CIRRATULUS CIRRATUS	9	1	--	--	3	13
HAPLOSCOLOPLOS PUGETTENSIS	7	2	4	--	3	15
GLYCINDE SP.	1	7	3	--	13	29

Table 22 (Continued)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY					SPECIMEN TOTAL
	SURVEY					
	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	
CIRRIFORMIA SPIRABRANCHA	1	--	--	--	1	2
PSEUDOPOLYDORA KEMPI CALIFORNICA	7	17	105	17	16	162
SCHISTOMERINGOS LONGICORNIS		6	11	20	5	49
STREBLOSPIO BENEDICTI	4	135	84	31	200	454
HARMOTHOE IMBRICATA	--	3	3	10	12	28
CAPITELLA CAPITATA	--	15	26	3	42	86
POLYDORA LIGNI	--	4	3	20	58	85
ETEONE LONGA CALIFORNICA	--	1	1	--	65	67
AUTOLYTUS SP.	--	1	2	--	--	3
POLYDORA SP.	--	1	--	--	--	1
HARMOTHOE SP.	--	2	2	8	--	12
ETEONE DILATAE	--	2	--	--	--	2
THARYX PARVUS	--	--	8	--	--	8
ETEONE LIGHTI	--	--	3	1	26	30
THARYX SP.	--	--	3	--	2	5
MARPHYSA SANGUINEA	--	--	3	3	2	8
CAPITELLIDAE-UNIDENTIFIED SPP.	--	--	--	4	--	4
ODONTOSYLLIS PARVA	--	--	--	20	--	20
ARTHROPODA						
AMPELISCA MILLERI	154	6531	60	55	774	7574
LEPTOCHELIA DUBIA	2	5	--	5	3	15
OSTRACODA-UNIDENTIFIED SPP.	50	54	1	--	--	105
COROPHIUM ACHERUSICUM	13	14	4	8	455	494
COPEPODA-UNIDENTIFIED SPP.	--	4	24	383	12	423
SARSIELLA ZOSTERICOLA	--	222	148	114	43	527
PYCNOGONIDA-UNIDENTIFIED SPP.	--	4	1	4	2	11
GRANDIDIERELLA JAPONICA	--	2	3	1	16	22
PARAPLEUSTES PUGETTENSIS	--	5	2	--	14	21
PYROMAIA TUBERCULATA	--	1	--	--	--	1
SYNIDOTEA LATICAUDA	--	31	4	1	3	39
CUMELLA VULGARIS	--	1	--	--	1	2
DECAPODA-UNIDENTIFIED SPP.	--	2	--	--	--	2
ACARINA-UNIDENTIFIED SPP.	--	--	43	2121	17	2181
COROPHIUM INSIDIOSUM	--	--	1	--	--	1
PARAPLEUSTES SP.	--	--	--	1	--	1
COROPHIUM SP.	--	--	--	--	1	1
MOLLUSCA						
TAPES JAPONICA	113	153	791	142	7[illegible]	1572

Table 22 (Concluded)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY					SPECIMEN TOTAL
	SURVEY					
	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	
MUSCULUS SENHOUSIA	200	8	1	730	21	1010
UROSALPINX CINEREA	2	--	--	2	--	4
TSELLICA OVOIDEA	1	3	69	19	23	115
ADULA DIEGENSIS	1	--	--	--	--	1
MACOMA NASUTA	1	1	2	--	--	4
GEMMA GEMMA	--	--	60	1	3	64
MYA ARENARIA	--	--	2	1	3	6
CREPIDULA CONVEXA	--	--	4	1	5	10
ODOSTOMIA (MENESTHO) FETELLA	--	--	1	--	--	1
OSTREA LURIDA	--	--	1	--	--	1
MACOMA BALTHICA	--	--	2	1	--	3
NUDIBRANCHIA-UNIDENTIFIED SPP.	--	--	5	--	6	11
CREPIDULA PLANA	--	--	--	1	--	1
BUSYCON CANALICULATUM	--	--	--	1	--	1
EPITONIUM TINCTUM	--	--	--	5	--	5
ECTOPROCTA						
MEMBRANIPORA PERFRAGILIS	P	--	--	--	--	P
MEMBRANIPORELLA SP.	--	--	P	--	--	P
CONOPEUM RETICULUM	--	--	P	P	--	P
CHEILOSTOMATA-UNIDENTIFIED SPP.	--	--	P	--	--	P
ALCYONIDIUM POLYOUM	--	--	--	P	P	P
ELECTRA CRUSTULENTA	--	--	--	P	P	P
CONOPEUM COMMENSALE	--	--	--	--	P	P
ALCYONIDIUM PARASITICUM	--	--	--	--	P	P
MEMBRANIPORA VILLOSA	--	--	--	--	P	P
SCRUPOCELLARIA SP.	--	--	--	--	P	P
CHORDATA						
ASCIDIACEA-UNIDENTIFIED SPP.	4	24	--	--	--	28
STYELA SP.	1	--	--	--	--	1
TUNICATA-UNIDENTIFIED SPP.	--	71	--	--	--	71
CIONA INTESTINALIS	--	--	23	14	90	127
FISH LARVAE	--	--	--	5	--	5
ENTOMATICA						
ENTOMATICA	1	--	--	--	1	2
GRAND TOTALS						
SPECIMENS	1486	9000	4527	7100	4721	32040
TAXA	39	45	55	57	51	91

Table 23

CONCENTRATIONS OF THE MOST ABUNDANT
BENTHIC ORGANISMS COLLECTED AT STATION SB-A
(Individuals per Liter)

	Percentage of Population*	Survey P (3/73)	Survey 1 (9/73)	Survey 2 (12/73)	Survey 3 (3/74)	Survey 4 (6/74)
Nematoda	8.7%	6.25	0.65	63.27	14.50	3.33
Oligochaeta	21.4	3.00	10.62	129.52	37.12	37.16
Polychaeta						
E. lourei	13.4	5.18	41.34	29.42	50.48	8.13
H. filiformis	2.7	3.61	1.73	5.26	7.60	7.38
Sphaerosyllis sp.	2.2	0.02	2.02	4.62	15.73	0.63
P. caulleryi	1.8	0.45	11.82	1.15	3.62	0.66
S. benedicti	1.4	0.09	4.02	2.69	1.00	5.75
Arthropoda						
A. milleri	23.2	3.50	194.38	1.92	1.78	22.24
Acarina	6.7	0	0	1.38	68.64	0.49
S. zostericola	1.6	0	6.61	4.74	3.69	1.24
C. acherusicum	1.5	0.30	0.42	0.13	0.26	13.07
Copepoda	1.3	0	0.12	0.77	12.39	0.34
Mollusca						
T. japonica	6.0	2.57	4.61	25.35	4.82	21.95
M. senhousia	3.1	4.54	0.24	0.03	25.24	0.60
Total	95.0%	29.51	278.58	270.25	246.87	122.97
All organisms†	100.0	33.77	288.10	283.94	255.66	135.66

*Numerical percentage of all noncolonial organisms collected.

†All noncolonial organisms collected.

In March 1973, we recovered only 1,486 noncolonial specimens from our sediment samples, a sampling return that amounted to only 33.8/liter. Only 39 different taxa were found. In contrast, the average concentration of organisms in March 1974 was about 256/liter and 52 different taxa were collected. In March 1973, three of the abundant species were absent, and four of them numbered less than 1/liter.

During the next three surveys, the concentration of the animals in the sediment changed very little, the average for the three surveys being 275.9/liter, but the numerically dominant species changed from month to month. In September, the most abundant species was the arthropod *Ampelisca milleri*, constituting 67.5% of the total noncolonial specimen count and about 95% of the total arthropod count. *Sarsiella zostericola* accounted for over half of the remaining arthropod count in September and gradually decreased in number in the subsequent months. The 50 unidentified ostracods collected in March 1973 may have been this species.

The polychaete *Exogone lourei* was the second most abundant animal collected in September, accounting for 14.3% of the total noncolonial specimen count. This organism was the most abundant polychaete for each sampling month. Approximately 68% of all specimens of *Polydora caulleryi* were collected in September.

In December, the oligochaetes were the most abundant, and they made up about 46% of the noncolonial organisms collected. The nematodes were the second most abundant animal type. Together, the oligochaetes and the nematodes constituted 67.9% of the total population count in December. During this month, we also observed a significant increase in the number of *Tapes japonica*, a mollusc present during all five surveys but most (and equally) abundant in December 1973 and June 1974.

In March 1974, we removed a large number of aquatic mites (Acarina) from our samples. These arthropods constituted 26.8% of the 7,900 noncolonial organisms collected during that month, and they were the most abundant organisms. We did not encounter any of them in the March and September 1973 samples, but we collected a total of 60 in December 1973 and June 1974.

The polychaete _E_. _lourei_ was the third most abundant animal collected at SB-A during the study and was most abundant in March 1974. In March 1974, we also observed a sizable increase in the number of _Musculus senhousia_, a mollusc that accounted for about 81% of all molluscs collected during that month. Other organisms that were more abundant in March than in any other month were the polychaete _Sphaerosyllis_ sp., the mollusc _Musculus senhousia_, and the copepods.

Between March and June 1974, the size of the benthic population at SB-A decreased by about 47%. Although they were no more numerous than in the previous sampling month, the oligochaetes were the most abundant organism collected in June. The arthropods _Ampelisca milleri_ and _Corophium acherusicum_ became more abundant than in the two previous sampling months.

Station SB-B

The sediment at Station SB-B was not disturbed by disposal operations during the study. We collected approximately the same number of noncolonial organisms and a few more taxa at this station than at SB-A. The numerically dominant taxa were essentially the same at both stations.

The taxa identified at SB-B included 35 Polychaeta, 21 Arthropoda, 18 Mollusca, and 8 Ectoprocta. The 91 taxa are shown according to survey in Table 24, and the 15 most abundant types with concentrations are presented in Table 25. These abundant forms constituted about 93% of the total number of noncolonial organisms collected.

The compositions of the benthic communities at SB-A and SB-B were different; 12 taxa belonging to the three major groups (Polychaeta, Arthropoda, and Mollusca) were found exclusively at SB-A, and 22 taxa were found only at SB-B. These mutually exclusive organisms were of little numerical significance, the total number of organisms representing these 30 taxa amounting to only 0.27% of the total number of noncolonial specimens collected at both stations.

Table 24

DISTRIBUTION AND ABUNDANCE OF SPECIES AT STATION SB-B

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY — SURVEY P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	SPECIMEN TOTAL
PROTOZOA						
FORAMINIFERA-UNIDENTIFIED SPP.	--	--	--	--	3	3
PORIFERA						
KERATOSA-UNIDENTIFIED SPP.	P	--	--	--	--	P
DEMOSPONGIAE-UNIDENTIFIED SPP.	--	--	--	--	P	P
CNIDARIA						
DIADUMENE SP.	1	1	--	--	--	2
HALIPLANELLA SP.	10	--	--	--	--	10
GONOTHYRAEA SP.	--	P	--	--	--	P
CAMPANULARIA SP.	--	--	P	P	P	P
HYDROZOA-UNIDENTIFIED SPP.	--	--	--	--	P	P
NEMERTEA						
NEMERTEA-UNIDENTIFIED SPP.	23	4	1	--	--	28
NEMATODA						
NEMATODA-UNIDENTIFIED SPP.	285	--	962	3	36	1286
ANNELIDA-OLIGOCHAETA						
OLIGOCHAETA-UNIDENTIFIED SPP.	461	55	2125	910	680	4241
ANNELIDA-POLYCHAETA						
CAPITELLA CAPITATA	6	2	11	2	91	112
HETEROMASTUS FILIFORMIS	40	123	498	281	171	1113
COSSURA PYGODACTYLATA	7	9	116	14	16	162
ASYCHIS SP.	6	19	102	45	69	241
PSEUDOPOLYDORA KEMPI CALIFORNICA	1	5	84	75	111	276
PSEUDOPOLYDORA PAUCIBRANCHIATA	184	--	2	--	--	186
STREBLOSPIO BENEDICTI	3	71	783	101	1534	2492
NEPHTYS CAECOIDES	8	--	--	--	--	8
EXOGONE LOUREI	1094	224	2159	401	645	4523
SPHAEROSYLLIS SP.	36	--	274	41	98	449
SCHISTOMERINGOS LONGICORNIS	3	5	99	13	12	132

Table 24 (Continued)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY — SURVEY P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	SPECIMEN TOTAL
MEDIOMASTUS CALIFORNIENSIS	1	--	--	--	1	2
ETEONE LONGA CALIFORNICA	1	--	28	9	155	193
HAPLOSCOLOPLOS PUGETTENSIS	1	--	11	4	3	19
GLYCINDE SP.	2	1	1	1	22	27
CIRRATULUS CIRRATUS	--	8	361	44	41	454
POLYDORA CAULLERYI	--	229	--	16	52	399
HARMOTHOE IMBRICATA	--	1	5	2	22	30
ETEONE LIGHTI	--	--	20	3	27	50
POLYDORA LIGNI	--	--	206	238	141	585
POLYNOIDAE-UNIDENTIFIED SPP.	--	--	2	--	--	2
CIRRIFORMIA SPIRABRANCHA	--	--	1	--	--	1
LUMBRINERIDAE-UNIDENTIFIED SPP.	--	--	1	--	--	1
NEPHTYS CORNUTA FRANCISCANA	--	--	1	--	--	1
SCHISTOMERINGOS SP. - JUVENILE	--	--	4	--	--	4
LYSIDICE NINETTA	--	--	30	--	1	31
POLYDORA CAECA	--	--	2	--	--	2
AUTOLYTUS SP.	--	--	3	--	--	3
EUMIDA SP.	--	--	1	--	--	1
HARMOTHOE SP.	--	--	1	2	--	3
THARYX SP.	--	--	1	1	--	2
CHAETOZONE SP.	--	--	1	1	--	2
THARYX PARVUS	--	--	--	1	--	1
MARPHYSA SANGUINEA	--	--	--	2	--	2
TROCHOCHAETA MULTISETOSUM	--	--	--	--	1	1
ARTHROPODA						
OSTRACODA-UNIDENTIFIED SPP.	22	36	--	--	--	58
COROPHIUM ACHERUSICUM	158	4	2	--	887	1051
GRANDIDIERELLA JAPONICA	7	4	5	1	14	31
AMPELISCA MILLERI	252	5323	345	73	4907	10900
SYNIDOTEA LATICAUDA	2	3	--	--	3	8
CUMACEA-UNIDENTIFIED SP. A	1	--	--	--	--	1
COROPHIUM INSIDIOSUM	5	3	--	--	--	8
INSECTA-UNIDENTIFIED SPP.	1	--	--	--	--	1
SARSIELLA ZOSTERICOLA	--	9	121	57	139	336
LEPTOCHELIA DUBIA	--	9	78	10	2	99
PYCNOGONIDA-UNIDENTIFIED SPP.	--	4	7	3	36	50
PARAPLEUSTES PUGETTENSIS	--	5	--	8	[illegible]	77
ARACHNIDA-UNIDENTIFIED SPP.	--	1	--	--	--	1
LIMNORIA QUADRIPUNCTATA	--	--	1	--	--	1

Table 24 (Continued)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY — SURVEY P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	SPECIMEN TOTAL
COPEPODA-UNIDENTIFIED SPP.	--	--	271	2	3	276
ACARINA-UNIDENTIFIED SPP.	--	--	1856	--	3	1364
SARSIELLA SP.	--	--	25	--	--	25
CIRRIPEDIA-UNIDENTIFIED SPP.	--	--	21	--	--	21
COROPHIUM SP.	--	--	1	--	--	1
CUMELLA VULGARIS	--	--	--	--	4	4
ISOPODA-UNIDENTIFIED SPP.	--	--	--	--	3	3
MOLLUSCA						
MUSCULUS SENHOUSIA	99	12	205	14	24	354
TAPES JAPONICA	6	94	111	59	39	309
GEMMA GEMMA	14	1	1	--	3	19
CREPIDULA CONVEXA	2	--	6	2	--	10
MACOMA NASUTA	1	1	1	--	1	4
ODOSTOMIA (EVALEA) SP.	9	--	--	--	--	9
ODOSTOMIA (EVALEA) FRANCISCANA	1	--	--	--	--	1
ODOSTOMIA (MENESTHO) FETELLA	1	--	--	--	--	1
UROSALPINX CINEREA	1	--	--	--	--	1
NASSARIUS OBSOLETUS	7	--	--	--	--	7
OSTREA LURIDA	1	--	1	--	--	2
ISELICA OVOIDEA	--	1	9	--	--	10
MYA ARENARIA	--	2	1	1	11	15
MACOMA BALTHICA	--	--	1	--	2	3
MACOMA SP. - JUVENILE	--	--	--	2	--	2
CREPIDULA PLANA	--	--	--	1	--	1
MACOMA INQUINATA	--	--	--	1	--	1
MYTILUS EDULIS	--	--	--	--	4	4
ECTOPROCTA						
SMITTOIDEA PROLIFICA	P	--	P	--	--	P
CONOPEUM RETICULUM	--	--	P	--	--	P
TRICELLARIA SP.	--	--	P	--	--	P
BOWERBANKIA GRACILIS	--	--	P	--	--	P
MEMBRANIPORA SP.	--	--	--	P	--	P
AETEA ANGUINA	--	--	--	P	--	P
ALCYONIDIUM POLYOUM	--	--	--	P	--	P
MEMBRANIPORA VILLOSA	--	--	--	--	P	P
CHORDATA						
ASCIDIACEA-UNIDENTIFIED SPP.	1	29	--	--	--	30

Table 24 (Concluded)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY: SURVEY P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	SPECIMEN TOTAL
TUNICATA-UNIDENTIFIED SPP.	--	40	--	--	--	40
CIONA INTESTINALIS	--	--	4	--	25	29
AMAROUCIUM SP.	--	--	P	--	--	P
FISH LARVAE	--	--	--	1	--	1
ENIGMATICA						
ENIGMATICA	1	--	--	--	--	1
GRAND TOTALS						
SPECIMENS	2765	6348	10969	2456	10124	32662
TAXA	43	35	60	43	47	99

Table 25

CONCENTRATIONS OF THE MOST ABUNDANT
BENTHIC ORGANISMS COLLECTED AT STATION SB-B
(Individuals per Liter)

	Percentage of Population*	Survey P (3/73)	Survey 1 (9/73)	Survey 2 (12/73)	Survey 3 (3/74)	Survey 4 (6/74)
Nematoda	3.9%	5.48	0	28.63	0.09	1.09
Oligochaeta	13.0	8.87	1.92	63.24	28.09	20.61
Polychaeta						
E. lourei	13.8	21.04	6.61	64.26	12.38	19.55
S. benedicti	7.6	0.06	2.09	23.30	3.12	46.48
H. filiformis	3.4	0.77	3.63	14.82	8.67	5.18
P. ligni	1.8	0	0	6.13	7.35	4.27
C. cirratus	1.4	0	0.24	10.74	1.36	1.24
Sphaerosyllis sp.	1.4	0.69	0	8.15	1.27	2.97
P. caulleryi	0.9	0	6.76	0	0.56	1.88
Arthropoda						
A. milleri	33.4	4.85	157.02	10.27	2.25	148.70
Acarina	5.7	0	0	55.24	0	0.24
C. acherusicum	3.2	3.04	0.12	0.06	0	26.88
S. zostericola	1.0	0	0.27	3.60	2.07	4.21
Mollusca						
M. senhousia	1.1	1.90	0.35	6.10	0.43	0.73
T. japonica	0.9	0.12	2.77	3.30	1.82	1.18
Total	92.5%	46.82	181.79	297.84	69.46	285.21
All organisms†	100.0	53.17	187.26	326.46	75.80	306.79

*Numerical percentage of all noncolonial organisms collected.

†All noncolonial organisms collected.

Results and Discussion
Biological Characteristics
RCH-A

Although we collected a similar number of organisms at both stations, the size of the benthic population at SB-B fluctuated much more than that at SB-A. In March 1973, each liter of sediment contained an average of 53 organisms; in September, the average increased to about 187/liter; in December, the size of the population peaked at approximately 326/liter (Table 25). After a 76.8% decline in March 1974, the animal concentrations increased again to about 307/liter.

In March 1973, the benthic community at SB-B was dominated by the polychaete Exogone lourei, which constituted approximately 40% of the 2,765 organisms collected (Table 26). The size of the E. lourei population decreased considerably in September, when the arthropod Ampelisca milleri appeared in very large numbers (nearly 84% of the total number of noncolonial organisms).

Environmental conditions between September and December 1973 appeared to be favorable for population growth of many species, with 11 of the 13 generally abundant species showing marked numerical increases by December. Six arthropod and 14 polychaete species, including the polychaete Polydora ligni, appeared for the first time. That month we also encountered a large number of Acarina (aquatic mites), which were absent in the two preceding sampling months and in March 1974.

Redwood City Harbor

After we first surveyed the Redwood City Harbor area in March 1973, a substantial amount of sediment was removed from RCH-A by hopper dredge. Nevertheless, when we conducted the second survey of the area in September 1973, the numbers of the taxa and of specimens collected were not reduced. If our second survey had been conducted sooner after removal of the sediment, we might have found a reduction at least in the number of animals.

Station RCH-A

Table 26 lists the taxa collected at Station RCH-A by survey. The most abundant species in all surveys was the arthropod

Table 26

DISTRIBUTION AND ABUNDANCE OF SPECIES AT STATION RCH-A

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY — SURVEY P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	SPECIMEN TOTAL
PROTOZOA						
FORAMINIFERA-UNIDENTIFIED SPP.	--	4	1	7	11	23
PORIFERA						
HEXACTINELLIDA-UNIDENTIFIED SPP.	--	--	--	--	P	P
PORIFERA-UNIDENTIFIED SPP.	--	--	--	--	P	P
CNIDARIA						
DIADUMENE SP.	15	--	2	2	--	19
HALIPLANELLA SP.	9	6	--	--	--	15
GONOTHYRAEA SP.	P	P	--	--	--	P
CAMPANULARIA SP.	--	--	P	P	P	P
HYDROZOA-UNIDENTIFIED SPP.	--	--	--	--	P	P
CNIDARIA-UNIDENTIFIED SPP.	--	--	--	--	1	1
SERTULARIA SP.	--	--	--	--	P	P
PLATYHELMINTHES						
? ACOELA-UNIDENTIFIED SPP.	1	--	--	--	--	1
NEMERTEA						
NEMERTEA-UNIDENTIFIED SPP.	21	3	--	1	--	25
NEMATODA						
NEMATODA-UNIDENTIFIED SPP.	58	741	462	617	1322	3200
ANNELIDA-OLIGOCHAETA						
OLIGOCHAETA-UNIDENTIFIED SPP.	78	2449	2166	1261	9881	15835
ANNELIDA-POLYCHAETA						
CAPITELLA CAPITATA	8	1	--	2	37	48
HETEROMASTUS FILIFORMIS	23	165	51	55	243	583
HETEROMASTUS SP.	1	--	--	--	--	1
COSSURA PYGODACTYLATA	52	--	19	210	102	383
PSEUDOPOLYDORA PAUCIBRANCHIATA	92	15	57	1	--	163
SCHISTOMERINGOS LONGICORNIS	1	--	--	2	15	19

Table 26 (Continued)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY — SURVEY P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	SPECIMEN TOTAL
EXOGONE LOUREI	177	1739	589	882	1030	4417
HAPLOSCOLOPLOS PUGETTENSIS	2	--	--	2	1	5
MARPHYSA SANGUINEA	1	16	5	--	27	49
GLYCINDE SP.	2	6	1	2	22	33
ASYCHIS SP.	19	4	3	40	10	76
PSEUDOPOLYDORA KEMPI CALIFORNICA	1	4	1	47	220	273
NEPHTYS CAECOIDES	1	--	--	--	--	1
SPHAEROSYLLIS SP.	2	104	146	345	257	654
DORVILLEIDAE-UNIDENTIFIED SPP.	1	--	--	--	--	1
THARYX SP.	1	--	--	5	--	6
ETEONE LONGA CALIFORNICA	--	7	2	4	170	183
POLYNOIDAE-UNIDENTIFIED JUVENILE	--	1	--	--	--	1
POLYDORA CAULLERYI	--	4	--	--	--	4
HARMOTHOE IMBRICATA	--	13	--	5	29	47
STREBLOSPIO BENEDICTI	--	30	3	313	2139	2485
POLYDORA LIGNI	--	258	462	175	88	983
POLYCIRRUS SP.	--	2079	4	1	3	2087
DORVILLEA SP.	--	1	--	--	--	1
POLYCHAETA-UNIDENTIFIED SPP.	--	1	--	--	--	1
POLYCIRRUS SP., NEAR TENUISETIS	--	1	--	--	--	1
ETEONE LIGHTI	--	--	1	2	110	113
PYGOSPIO SP.	--	--	1	--	--	1
POLYNOIDAE-UNIDENTIFIED SPP.	--	--	--	2	--	2
TEREBELLIDAE-UNIDENTIFIED SPP.	--	--	--	4	--	4
HARMOTHOE SP.	--	--	--	3	--	3
CAPITELLA SP.	--	--	--	2	1	3
AUTOLYTUS SP.	--	--	--	1	--	1
STREPTOSYLLIS SP.	--	--	--	--	1	1
SYLLIDAE-UNIDENTIFIED SPP.	--	--	--	--	1	1
ARTHROPODA						
COROPHIUM INSIDIOSUM	3	16	1	--	--	20
AMPELISCA MILLERI	339	11553	5934	1975	4165	24026
PYROMAIA TUBERCULATA	1	--	--	--	--	1
OSTRACODA-UNIDENTIFIED SPP.	6	--	--	--	--	6
LEPTOCHELIA DUBIA	1	--	3	1	--	5
COROPHIUM ACHERUSICUM	1	15	--	13	296	325
SARSIELLA ZOSTERICOLA	--	165	183	229	264	842
INSECTA-UNIDENTIFIED SPP.	--	1	--	--	2	3
GRANDIDIERELLA JAPONICA	--	16	31	2	20	69

Table 26 (Continued)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY — SURVEY P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	SPECIMEN TOTAL
COROPHIUM SP.	--	2	4	1	--	7
PARAPLEUSTES PUGETTENSIS	--	1	--	--	10	11
SYNIDOTEA LATICAUDA	--	24	--	2	1	27
PYCNOGONIDA-UNIDENTIFIED SPP.	--	1	--	2	--	3
COPEPODA-UNIDENTIFIED SPP.	--	4	36	72	182	294
CUMELLA VULGARIS	--	1	--	--	20	21
ACARINA-UNIDENTIFIED SPP.	--	--	185	569	857	1611
SARSIELLA SP.	--	--	4	--	--	4
SYNIDOTEA SP.	--	--	1	--	6	7
BALANUS IMPROVISUS	--	--	--	--	1	1
HEMIGRAPSUS OREGONENSIS	--	--	--	--	1	1
MOLLUSCA						
EPITONIUM TINCTUM	1	--	--	--	--	1
UROSALPINX CINEREA	5	1	--	--	--	6
NASSARIUS OBSOLETUS	2	--	--	--	1	3
ODOSTOMIA (MENESTHO) FETELLA	2	--	--	--	--	2
MYA ARENARIA	1	--	1	--	2	4
TAPES JAPONICA	73	47	20	27	340	507
GEMMA GEMMA	1	1	--	1	7	10
MUSCULUS SENHOUSIA	414	141	143	28	10	736
MACOMA NASUTA	4	--	-	5	3	12
MACOMA BALTHICA	1	--	--	--	--	1
ODOSTOMIA (EVALEA) VALDEZI	1	--	--	--	--	1
CREPIDULA CONVEXA	--	6	--	--	--	6
MACOMA BALTHICA - JUVENILE	--	--	1	--	--	1
MYTILUS EDULIS	--	--	--	--	2	2
ECTOPROCTA						
MEMBRANIPORA MEMBRANACEA	--	P	--	--	--	P
ELECTRA ARCTICA	--	--	P	--	P	P
ECTOPROCTA-UNIDENTIFIED SPP.	--	--	--	P	--	P
MEMBRANIPORA VILLOSA	--	--	--	--	P	P
MEMBRANIPORELLA SP.	--	--	--	--	P	P
CHORDATA						
ASCIDIACEA-UNIDENTIFIED SPP.	2	--	--	--	--	2
CIONA INTESTINALIS	--	--	1	--	2	3

Table 26 (Concluded)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY: SURVEY P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	SPECIMEN TOTAL
ENIGMATICA						
ENIGMATICA	1	--	--	--	--	1
GRAND TOTALS						
SPECIMENS	1425	19671	10614	6921	21914	60545
TAXA	42	43	36	44	53	91

Ampelisca milleri. This amphipod constituted 39.7% of the total noncolonial specimen count. The oligochaetes were also very numerous, accounting for 26.2% of the benthic organisms collected. Table 27 lists other abundant organisms including the oligochaetes and *A. milleri*.

In March 1973, we collected 42 types of organisms at RCH-A. These organisms comprised the nemerteans, nematodes, and oligochaetes, as well as 16 species of polychaetes, six species of arthropods, and 11 species of molluscs. A total of 1,425 noncolonial organisms, amounting to about 27 organisms/liter, were collected. The mollusc *Musculus senhousia* and the arthropod *Ampelisca milleri* were the most abundant species, constituting 52.8% of all noncolonial organisms collected during March 1973. A relatively large number of the polychaete *Exogone lourei* also was found.

In September 1973, we collected about the same number of species as in March, but the concentration of organisms was about 20 times greater in September. The taxa included 19 species of polychaetes, 12 species of arthropods, and 5 species of molluscs.

Ten of the polychaetes collected in September 1973 were not present during the preliminary survey (Table 26). These included three of the species we classified as abundant, *Streblospio benedicti*, *Polydora ligni*, and *Polycirrus* sp., the latter accounting for 46.5% of the total number of polychaetes collected in September. Only three of the 15 species of arthropods collected in March and September 1973 were common to both months. Of the nine collected in September, *Grandidierella japonica*, *Corophium insidiosum*, *Synidotea laticauda*, and possibly *Sarsiella zostericola** were absent in March. *Tapes japonica* and *Musculus senhousia* were the most abundant molluscs in March and September 1973. In March, we collected 14 species of molluscs, but, in September, we collected only 5 species of which one was not present in March.

*The unidentified ostracods may have been this species.

Table 27

CONCENTRATIONS OF THE MOST ABUNDANT
BENTHIC ORGANISMS COLLECTED AT STATION RCH-A
(Individuals per Liter)

	Percentage of Population*	Survey				
		P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)
Nematoda	5.3%	1.12	22.45	14.13	20.57	42.37
Oligochaeta	26.2	1.50	74.21	66.24	42.03	316.70
Polychaeta						
E. lourei	7.3	3.40	52.70	18.01	29.40	33.01
S. benedicti	4.1	0	0.91	0.09	10.43	68.56
Polycirrus sp.	3.4	0	63.00	0.12	0.03	0.10
P. ligni	1.6	0	7.82	14.13	5.83	2.82
Sphaerosyllis sp.	1.4	0.04	3.15	4.46	11.50	8.24
Arthropoda						
A. milleri	39.7	6.52	350.09	183.30	65.83	133.49
Acarina	2.7	0	0	5.66	18.97	27.47
S. zostericola	1.4	0	5.03	5.60	7.63	8.46
Mollusca						
M. senhousia	1.2	7.96	4.27	4.37	0.93	0.32
Total	94.3%	20.54	583.63	316.11	213.15	641.54
All organisms†	100.0	27.40	596.09	324.59	230.70	702.37

*Numerical percentage of all noncolonial organisms collected.

†All noncolonial organisms collected.

Fewer species--36--were collected in December 1973 than in the previous sampling period. Our collection included 15 polychaete, 10 arthropod, and 4 mollusc species. Seven of the polychaete species present in September 1973 were absent in December, and two--namely, Eteone lighti and Pygospio sp.--were absent in March and September 1973. In December, we found three types of arthropod for the first time, and one of them, the Acarina, was relatively numerous. The decline in population size in December was caused primarily by a decrease in the number of Ampelisca milleri, Exogone lourei, and Polycirrus sp. The additional reduction observed in March 1974 was attributable to a 81.1% decrease in the size of the Ampelisca milleri population.

In June 1974, the size of the benthic population peaked. We collected approximately 702/liter. A total of 53 taxa--more than collected in any other month--were identified. The increased benthic population was attributable to a considerable increase in the number of nematodes, oligochaetes, Ampelisca milleri, and Streblospio benedicti. S. benedicti was absent in March 1973 and numbered less than 1/liter in September and December. The number collected increased significantly in March 1974, but the largest number was collected in June.

Station RCH-B

At Station RCH-B, we collected fewer species and about half the number of organisms as we did at RCH-A. Table 28 lists the types of organisms collected and the number recovered during each survey. As at RCH-A, the arthropod Ampelisca milleri was the most abundant organism at RCH-B, accounting for 32.3% of all noncolonial specimens and 84.9% of all arthropods. Although we found a large number of oligochaetes, we collected a larger number of the polychaete Streblospio benedicti, which constituted about 25% of all noncolonial organisms collected. Table 29 lists the 12 most abundant organisms found at RCH-B. Together, they constituted 95.5% of total noncolonial organisms collected.

The density of the benthic population was least in March 1973, when we collected organisms at the rate of about 38/liter of sediment (about 10 more than at RCH-A). The population

Table 28

DISTRIBUTION AND ABUNDANCE OF SPECIES AT STATION RCH-B

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY					SPECIMEN TOTAL
	SURVEY					
	? (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	
PROTOZOA						
FORAMINIFERA-UNIDENTIFIED SPP.	--	--	44	98	520	662
CNIDARIA						
HYDROZOA-UNIDENTIFIED SPP.	P	--	--	--	P	P
DIADUMENE SP.	62	--	--	--	--	62
HALIPLANELLA SP.	20	--	--	--	--	20
GONOTHYRAEA SP.	P	--	--	--	--	P
CALYPTOBLASTEA-UNIDENTIFIED SPP.	P	--	--	--	--	P
CAMPANULARIA SP.	--	--	P	P	--	P
SYNCORYNE SP.	--	--	--	--	P	P
NEMERTEA						
NEMERTEA-UNIDENTIFIED SPP.	32	9	17	11	8	77
NEMATODA						
NEMATODA-UNIDENTIFIED SPP.	114	47	251	232	1564	2208
ANNELIDA-OLIGOCHAETA						
OLIGOCHAETA-UNIDENTIFIED SPP.	302	129	699	1429	2921	5480
ANNELIDA-POLYCHAETA						
HETEROMASTUS FILIFORMIS	334	62	37	37	51	551
COSSURA PYGODACTYLATA	24	46	204	229	76	579
ASYCHIS SP.	52	2	--	--	4	58
HAPLOSCOLOPLOS PUGETTENSIS	5	1	--	--	--	6
POLYDORA SOCIALIS	2	--	--	--	--	2
PSEUDOPOLYDORA KEMPI CALIFORNICA	[illegible]	24	48	56	24	173
PSEUDOPOLYDORA SP.	1	--	--	--	--	1
STREBLOSPIO BENEDICTI	3	693	2655	3944	1242	6777
SCHISTOMERINGOS LONGICORNIS	17	--	2	2	2	23
GLYCINDE SP.	2	--	--	--	4	11
HARMOTHOE IMBRICATA	2	--	--	--	--	2
EXOGONE LOURE!	356	41	273	58	439	1187
SPHAEROSYLLIS SP.	6	--	33	4	334	431

Table 28 (Continued)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY — SURVEY P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	SPECIMEN TOTAL
POLYDORA CAULLERYI	7	--	--	--	--	7
POLYDORA SOCIALIS	6	--	--	--	--	6
PSEUDOPOLYDORA PAUCIBRANCHIATA	12	23	38	--	1	74
CIRRATULUS CIRRATUS	5	--	--	--	--	5
CIRRIFORMIA SPIRABRANCHA	1	--	1	--	--	2
CHAETOZONE SP.	1	--	--	--	--	1
NEPHTYS CAECOIDES	1	1	--	1	--	3
CAPITELLA CAPITATA	--	2	19	9	21	51
THARYX PARVUS	--	--	1	--	--	1
POLYDORA LIGNI	--	--	4	1	9	14
CAPITELLIDAE-UNIDENTIFIED SPP.	--	--	--	2	2	4
ETEONE LIGHTI	--	--	--	1	244	245
NEANTHES SUCCINEA	--	--	--	2	--	2
ETEONE LONGA CALIFORNICA	--	--	--	--	5	5
HARMOTHOE SP.	--	--	--	--	1	1
SPIONIDAE-UNIDENTIFIED JUVENILE	--	--	--	--	1	1
MEDIOMASTUS CALIFORNIENSIS	--	--	--	--	3	3
SIPUNCULA						
SIPUNCULA-UNIDENTIFIED SPP.	1	--	--	--	--	1
ARTHROPODA						
COPEPODA-UNIDENTIFIED SPP.	2	--	55	2	677	736
LEPTOCHELIA DUBIA	2	--	--	--	--	2
PYROMAIA TUBERCULATA	4	--	--	--	--	4
OSTRACODA-UNIDENTIFIED SPP.	10	7	--	--	4	21
AMPELISCA MILLERI	65	1195	2254	2241	5438	11193
COROPHIUM ACHERUSICUM	1	--	--	2	245	248
COROPHIUM SP.	2	--	--	--	--	2
PYCNOGONIDA-UNIDENTIFIED SPP.	3	--	1	1	1	6
HYDRACARINA-UNIDENTIFIED SPP.	15	--	--	--	--	15
SYNIDOTEA BICUSPIDA	--	1	--	--	--	1
SARSIELLA ZOSTERICOLA	--	14	270	146	360	790
GRANDIDIERELLA JAPONICA	--	6	2	--	72	80
SYNIDOTEA LATICAUDA	--	2	--	--	--	2
ARACHNIDA-UNIDENTIFIED SPP.	--	--	1	--	--	1
CUMELLA VULGARIS	--	--	--	--	64	64
ACARINA-UNIDENTIFIED SPP.	--	--	--	--	17	17
SYNIDOTEA HARFORDI	--	--	--	--	1	1

Table 28 (Concluded)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY					SPECIMEN TOTAL
	SURVEY					
	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	
MOLLUSCA						
TAPES JAPONICA	91	3	4	4	1	103
MUSCULUS SENHOUSIA	360	25	29	28	61	503
ODOSTOMIA (EVALEA) VALDEZI	1	--	--	3	1	5
NASSARIUS OBSOLETUS	2	--	1	--	1	4
ISELICA OVOIDEA	1	--	--	--	--	1
MYA ARENARIA	--	1	1	--	39	41
MACOMA NASUTA	--	1	4	1	6	12
MACOMA BALTHICA	--	1	--	4	--	5
ODOSTOMIA (EVALEA) SP. A	--	--	1	--	--	1
GEMMA GEMMA	--	--	5	4	16	25
ODOSTOMIA (EVALEA) FRANCISCANA	--	--	1	--	1	2
ODOSTOMIA (EVALEA) TENUISCULPTA	--	--	1	--	--	1
ODOSTOMIA (EVALEA) SP.	--	--	--	1	--	1
SILIQUA PATULA	--	--	--	--	1	1
MYTILUS EDULIS	--	--	--	--	1	1
PHORONIDA						
CF PHORONOPSIS SP.	--	1	--	--	--	1
CHORDATA						
UROCHORDATA-UNIDENTIFIED SPP.	13	--	--	--	--	13
STYELA SP.	1	--	--	--	--	1
ASCIDIACEA-UNIDENTIFIED SPP.	3	--	--	--	--	3
TUNICATA-UNIDENTIFIED SPP.	P	--	--	--	--	P
CIONA INTESTINALIS	--	--	--	1	--	1
ENIGMATICA						
ENIGMATICA	2	--	--	--	--	2
GRAND TOTALS						
SPECIMENS	1965	2337	7236	8526	14532	34546
TAXA	48	25	32	31	44	81

Table 29

CONCENTRATIONS OF THE MOST ABUNDANT
BENTHIC ORGANISMS COLLECTED AT STATION RCH-B
(Individuals per Liter)

	Percentage of Population*	Survey P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)
Protozoa						
Foraminifera	1.9%	0	0	1.38	3.14	16.83
Nematoda	6.4	2.13	1.46	8.21	6.47	51.26
Oligochaeta	15.8	5.64	4.02	21.98	45.80	94.53
Polychaeta						
S. benedicti	25.3	0.06	21.59	89.78	126.41	41.49
E. lourei	3.4	6.65	1.28	9.21	1.86	14.21
C. pygodactylata	1.7	0.45	1.43	6.42	7.34	2.46
H. filiformis	1.6	6.24	1.93	1.16	1.19	2.62
Sphaerosyllis sp.	1.2	0.11	0	2.61	0.13	10.94
Arthropoda						
A. milleri	32.3	1.21	37.23	70.88	71.83	175.99
S. zostericola	2.3	0	0.44	8.49	1.68	11.65
Copepoda	2.1	0.04	0	1.73	0.06	21.91
Mollusca						
M. senhousia	1.5	6.73	0.78	0.91	0.90	1.97
Total	95.5%	29.26	70.16	222.76	269.81	445.86
All organisms†	100.0	36.73	72.80	227.55	273.27	471.91

*Numerical percentage of all noncolonial organisms collected.

†All noncolonial organisms collected.

was dominated by several species, including Exogone lourei and Heteromastus filiformis, which are polychaetes; Musculus senhousia, a mollusc; and the oligochaetes. The concentration of each of these organisms fell in the range of 5.6 to 6.7/liter.

In September, the concentration of the organisms approximately doubled, and, in subsequent sampling months, the benthic population continued to increase in density, reaching a peak of about 472/liter in June 1974. The twofold increase in September was attributable principally to growth in the Streblospio benedicti and Ampelisca milleri populations. The animals that were abundant in March 1973 were considerably less numerous in September. In March, only 3.5% of the noncolonial organisms were S. benedicti and A. milleri, the two species that constituted nearly 81% of the September census.

The population in December 1973 was a little over three times greater than it was in the previous sampling month. Most of the generally abundant taxa were more numerous. About 80% of the animals collected were S. benedicti, A. milleri, and oligochaetes. Of these three taxa, S. benedicti was the most numerous, and the oligochaetes were the least numerous.

In March 1974, the S. benedicti population peaked. About 46% of the noncolonial animals collected during that month were of that species. The sediment samples contained twice as many oligochaetes per liter than the samples collected in December, but about the same number of A. milleri. Most of the organisms collected in March were S. benedicti, oligochaetes, and A. milleri.

In June 1974, 7 of the 11 taxa listed in Table 29 were more numerous than in any other month. These were the nematodes, oligochaetes, Exogone lourei, Sphaerosyllis sp., Ampelisca milleri, Sarsiella zostericola, and copepoda. Ampelisca milleri was the most abundant species, followed by the oligochaetes and nematodes.

Common Taxa

Table 30 lists the organisms present during each of the five surveys. Of the approximately 341 taxa collected at the 11 stations between March 1973 and June 1974, only 43 were common.

The oligochaetes and nematodes were most widely distributed, the oligochaetes being common at all stations and the nematodes being common at all stations except SB-B, where they were generally few and were absent in September 1973. The polychaete *Streblospio benedicti* was common at seven of the stations.

The Central and South San Francisco Bay stations, excluding ALC, generally attracted the greatest variety of year-round resident organisms. However, the northern stations, including ALC, seemed to be suitable for certain species that were not found commonly elsewhere. The copepods were present during each survey only at MIS-A and MIS-B. The clam *Mya arenaria* was common only at MIS-B, CS-A, and CS-B; and another clam, *Macoma balthica*, was common only at MIS-B. ALC was inhabited by only three common benthic forms--the nematodes, the oligochaetes, and the mollusc *Adula diegensis*, which was not common at any other station. Another species common to only one station was the bryozoan *Membranipora perfragilis*, present at MIS-A during all five surveys.

Physical and Chemical Characteristics

Water and Sediment Temperature

Figure 3 shows the fluctuations in average water and sediment temperatures measured at the 11 sampling stations during the five sampling periods. Water temperatures were determined on 2 water samples per station survey; the samples were collected about 3 ft off the bottom. Sediment temperatures were determined on 4 to 7 sediment samples. All temperatures were determined immediately after sample collection.

Table 30

COMMON BENTHIC ORGANISMS COLLECTED DURING ALL FIVE SURVEYS

	Station										
	MIS-A	MIS-B	CS-A	CS-B	ALC	OIH	HP	SB-A	SB-B	RCH-A	RCH-B
CNIDARIA											
Haliplanella sp.							x				
NEMERTEA						x	x				x
NEMATODA	x	x	x	x	x	x	x	x		x	x
OLIGOCHAETA	x	x	x	x	x	x	x	x	x	x	x
POLYCHAETA											
S. benedicti		x	x	x		x	x	x	x		x
E. lourei						x	x	x	x	x	x
M. californiensis							x				
H. filiformis								x	x	x	x
P. caulleryi								x			
Sphaerosyllis sp.						x	x	x		x	
C. pygodactylata							x	x	x		x
P. californiensis						x					
P. ligni						x					
P. kempi californica								x	x	x	x
S. squamata						x					

Table 30 (Continued)

	Station										
	MIS-A	MIS-B	CS-A	CS-B	ALC	OIH	HP	SB-A	SB-B	RCH-A	RCH-B
POLYCHAETA (continued)											
Glycinde sp.						x			x	x	
N. caecoides						x					
P. minuta						x					
N. cornuta franciscana						x	x				
E. longa californica						x					
C. capitata						x	x		x		
S. longicornis						x	x	x	x		
Asychis sp.							x	x	x	x	
C. cirratus							x				
A. brevis							x				
ARTHROPODA											
Copepoda	x	x									
A. milleri						x	x	x	x	x	x
L. dubia							x				
C. acherusicum								x			
P. franciscana						x					

Table 30 (Concluded)

	Station										
	MIS-A	MIS-B	CS-A	CS-B	ALC	OIH	HP	SB-A	SB-B	RCH-A	RCH-B
ARTHROPODA (continued)											
P. tuberculata							x				
G. japonica									x		
MOLLUSCA											
M. arenaria		x	x	x							
M. balthica		x									
G. gemma						x					
T. japonica								x	x	x	x
M. senhousia						x	x	x	x	x	x
M. nasuta						x					
M. inquinata						x					
M. ferruginosa						x					
I. ovoidea								x			
A. diegensis					x						
ECTOPROCTA											
M. perfragilis	x										
Total	4	6	4	4	3	23	19	16	14	11	11

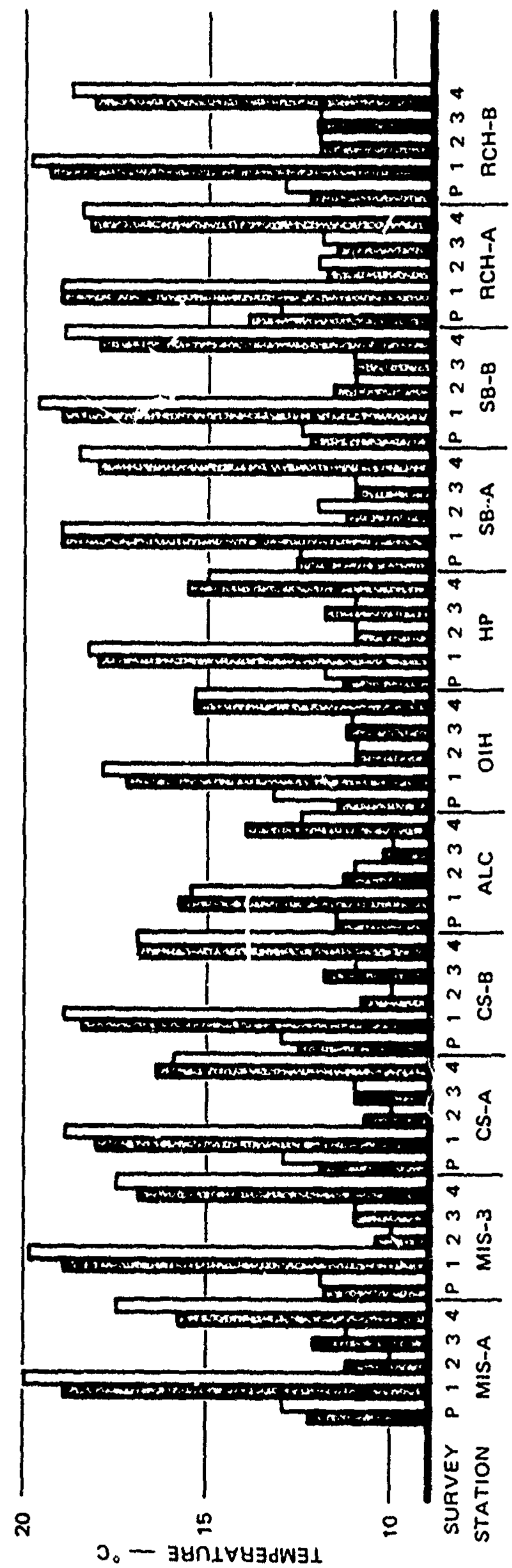

FIGURE 3 MEAN SEDIMENT AND WATER TEMPERATURE AT SELECTED DREDGE AND DISPOSAL AREAS IN SAN FRANCISCO BAY

Shaded bars = *sediment* temperature; unshaded bars = water temperature. Recording dates: P = March 1973; 1 = September 1973; 2 = December 1973; 3 = March 1974; 4 = June 1974.

Results and Discussion
Physical and Chemical Characteristics
Water and Sediment Temperature

Table 31 presents the means and ranges of water temperature at each station. Generally, temperature at ALC, OIH, and HP fluctuated less than that at other stations. The differences between the highest and the lowest mean temperatures recorded during the study ranged from 5.6°C at ALC to 7.8° at HP (Table 31). The water at these three Central San Francisco Bay stations was somewhat colder on the average than the water at the other stations.

Table 31

WATER TEMPERATURES: MEANS AND RANGES
(Degrees Celsius)

	Water Temperature		
	Mean (March 1973-June 1974)	Range*	
Station		Low	High†
MIS-A	14.2	9.9‡	20.0
MIS-B	14.1	10.0‡	19.8
CS-A	13.9	10.0‡	19.0
CS-B	14.0	10.0‡	19.0
ALC	12.1	10.0§	15.6
OIH	13.8	11.0‡	17.8
HP	13.4	11.0**	18.3
SB-A	14.6	11.0§	19.0
SB-B	14.6	11.0‡	19.7
RCH-A	14.9	11.8§	19.2
RCH-B	15.1	11.9§	19.8

*Values represent the average temperature of 2 water samples.

†All values recorded in September 1973.

‡Recorded in December 1973.

§Recorded in March 1974.

**Recorded in December 1973 and in March 1974.

At the northern section of the Bay, the water temperatures at the sites in Mare Island Strait and the Carquinez Strait disposal sites fluctuated as much as about 10°. At MIS-A, we recorded mean temperatures of 9.9° in December and 20.0° in September--the lowest and highest mean temperatures encountered during the study. In general, the average "seasonal" water temperature at the four northern stations was somewhat higher than that at the Central Bay stations.

The difference between the high and low mean temperatures at the stations at the South Bay disposal site and at Redwood City Harbor ranged from 7.4° at RCH-A to 8.7° at SB-B. On the average, the water temperature at these stations was higher than that at any other station.

Table 32 presents the mean "seasonal" sediment temperatures and the range for each station. As we found for water temperature, the sediment temperature fluctuated most at the northern stations and least at the central stations; and, on the average, the sediment was coldest at the central stations and warmest at the southern stations.

Salinity

We determined water salinity on two water samples per station per survey and collected the water samples from about 3 ft off the bottom. During March and June 1974, we also determined the salinity of the interstitial water, which was extracted from the sediment by centrifugation. Because of adverse weather conditions and other problems, we could not always collect samples during the same tide conditions.

Water salinity at MIS-A, MIS-B, CS-A, and CS-B was usually much lower and more variable than the salinity at other stations, as indicated in Figure 4. At MIS-A, the average salinity in the winter months was about 4 ‰; in June, the average salinity was 7.5 ‰; and, in September, it was 10.0 ‰. At MIS-B, the salinities during corresponding months (except September) were lower, ranging from 1.8 to 3.3 ‰ in the winter and averaging 6.3 ‰ in June.

Table 32

SEDIMENT TEMPERATURES: MEANS AND RANGES
(Degrees Celsius)

Station	Mean (March 1973-June 1974)	Range* Low	High†
MIS-A	13.9	11.0‡	18.8
MIS-B	13.8	10.4‡	19.0
CS-A	13.6	10.7‡	18.1
CS-B	14.0	10.8‡	18.4
ALC	12.6	10.2§	15.8
OIH	13.2	11.0‡	17.2
HP	13.5	11.0‡	18.0
SB-A	14.4	11.0§	19.0
SB-B	14.2	10.6‡	19.0
RCH-A	14.9	11.5§	19.0
RCH-B	14.7	11.9‡	19.3

*Values represent the average temperature of 3 to 7 sediment samples.

†All values recorded in September 1973.

‡Value recorded in December 1973.

§Value recorded in March 1974.

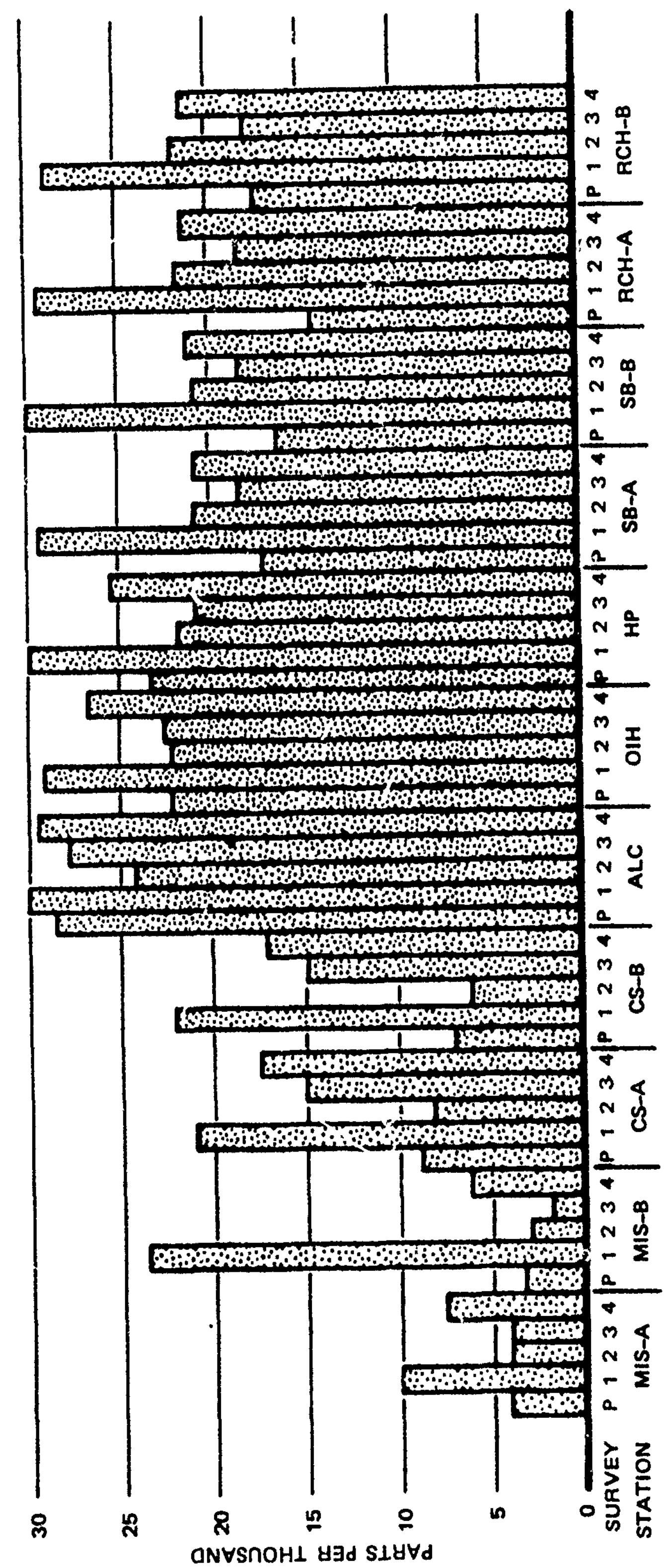

FIGURE 4 MEAN WATER SALINITY AT SELECTED DREDGE AND DISPOSAL AREAS IN SAN FRANCISCO BAY, 1973 and 1974

Recordings were made on water samples collected within three feet of the bottom. Recording dates: P = March 1973; 1 = September 1973; 2 = December 1973; 3 = March 1974; 4 = June 1974.

Results and Discussion

Physical and Chemical Characteristics

Salinity

The large difference in the salinity of the water collected from MIS-A and MIS-B in September probably is attributable to tide conditions. As shown in Table 33, we collected water samples from MIS-A during an outgoing tide and took samples from MIS-B during an incoming tide. Because Mare Island Strait is located in the tidewater region of the Napa River, tide conditions should have a great influence on salinity. However, during the winter, when rainfall is the heaviest, an incoming tide appears to have less influence on the salinity of water in tidewater areas than during drier periods. In March 1973, we collected water samples at MIS-A and MIS-B during an incoming tide; however, the salinity was no more than 4.2 ‰.

We found little difference between the salinity of water collected from CS-A and CS-B during the same sampling period. At these stations, the salinity was lowest in December, averaging about 6.6 ‰. The highest salinity was recorded in September and averaged about 21.5 ‰ for the two stations. Salinities recorded in March 1973 and March 1974 differed almost twofold. During these two months, we collected the water samples during an outgoing tide. In March 1973, however, the difference between high and low tide was 5.3 ft on the day of sampling, whereas a year later, the difference was 6.1 ft, which might account for the higher salinity observed in March 1974.

The Central San Francisco Bay stations at ALC, HP, and OIH appear to be influenced greatly by coastal marine conditions. The water in these areas was characterized by consistently high year-round salinity.

The water at ALC was quite saline throughout the study, ranging from 24.0 to 30.5 ‰ and averaging 27.8 ‰. Salinity was highest in September and lowest in December. The salinity readings taken at OIH and HP were essentially the same from survey to survey, and the average salinity over the five-survey period was 24.4 ‰ at both stations. During the winter months (March and December), the salinity was lower than during the summer months (June and September). In the winter, ranges were from 21.0 to 23.0 ‰ at OIH and from 20.5 to 24.0 ‰ at HP. In the summer, salinity ranged from 26.5 to 29.0 ‰ at OIH and from 25.0 to 30.0 ‰ at HP. At both stations, highest salinities were recorded in September.

Table 33

MEAN WATER SALINITY (PARTS PER THOUSAND) AND TIDE STATUS

Station	Survey P (March 1973) Salinity	Tide Status	Survey 1 (Sept. 1973) Salinity	Tide Status	Survey 2 (Dec. 1973) Salinity	Tide Status	Survey 3 (March 1974) Salinity	Tide Status	Survey 4 (June 1974) Salinity	Tide Status
MIS-A	4.2	I	10.0	O	4.0	I	4.0	O	7.5	LS
MIS-B	3.3	I	23.5	I	3.0	I	1.8	LS	6.3	LS
CS-A	8.8	O	21.0	O	7.0	I	15.2	O	17.5	O
CS-B	7.2	O	22.0	O	6.2	HS	14.8	O	17.0	O
ALC	28.5	LS	30.2	HS	24.2	O	27.8	O	29.5	HS
OIH	22.0	I	29.0	O	22.0	O	22.2	O	26.5	O
HP	23.6	O	30.0	LS	22.0	O	20.8	O	25.5	O
SB-A	17.3	I	29.5	O	21.0	O	18.5	HS	21.0	I
SB-B	16.5	O	30.0	O	21.0	O	18.5	HS	21.3	I
RCH-A	14.6	I	29.5	O	22.0	LS	18.5	O	21.5	I
RCH-B	17.6	O	29.0	I	22.0	LS	18.0	O	21.5	I

Note: I = Incoming
O = Outgoing
HS = High slack
LS = Low slack

Results and Discussion
Physical and Chemical Characteristics
Salinity

Salinities at all stations in the southern portion of San Francisco Bay were very similar during any given sampling month (Table 33). The lowest salinities were in March 1973. During this month, the average salinity ranged from 14.6‰ at RCH-A to 17.6‰ at RCH-B, and the mean for the four South Bay stations was 16.5‰. In March 1974, the average salinity at these stations was 18.4‰--slightly higher than in March of the previous year. In September 1973, the salinity was about as high as that encountered at the Central Bay stations. The four-station average was 29.5‰, and the range was 29.0 to 30.0‰. The salinity of the water at these stations was about the same in December 1973 and June 1974, when the averages for the four stations were 21.5 and 21.3‰, respectively.

Interstitial water salinity, determined on water extracted from sediment samples by centrifugation, was determined only during March 1974 and June 1974. In general, little difference existed between the salinity of the interstitial and the water from 3 ft above the bottom, as shown in Table 34. Relatively large differences were confined to stations in Mare Island Strait, where the salinity of the water is influenced greatly by tidal changes.

At MIS-A, the salinity of the water, taken during an outgoing tide on 6 March 1974, was 4.0‰. Interstitial water salinity averaged 9.1‰. At MIS-B, the salinity of the interstitial water was also higher than that of the water column, but the difference was only 3.6‰, which is not much greater than observed at some of the Central Bay stations. In June, the salinity of the interstitial water was also higher than water salinity, although the water and sediment samples were taken during an incoming tide. To determine how great an influence tidal changes have on interstitial water salinity requires a more extensive sampling schedule than that used in this study. With respect to the benthic organisms, knowing how much exchange occurs between the overlying water and interstitial water would be worthwhile.

Table 34

MEAN WATER AND INTERSTITIAL WATER SALINITIES
AT 11 STATIONS IN SAN FRANCISCO BAY*
(Parts per Thousand)

	Survey 3		Survey 4	
Station	Water	Sediment	Water	Sediment
MIS-A	4.0	9.1	7.5	10.8
MIS-B	1.8	5.4	6.2	9.9
CS-A	15.2	12.4	17.5	16.4
CS-B	14.8	13.7	17.0	15.5
ALC	27.8	23.4	29.5	29.6
OIH	22.2	24.0	26.5	26.7
HP	20.8	24.0	25.5	26.7
SB-A	18.5	18.4	21.0	21.9
SB-B	18.5	18.8	21.2	21.8
RCH-A	18.5	17.9	21.5	21.8
RCH-B	18.0	18.1	21.5	20.4

*Measurements were made in March and June 1974 (Surveys 3 and 4, respectively).

pH

The pH of the water collected from the 11 stations fell within a relatively narrow range. With the exception of one reading of 6.9, the range was 7.3 to 8.2, as shown in Table 35. In March 1973, the range was 7.7 to 8.0. In September 1973, the water at all stations was slightly more acidic than in the previous sampling period, the pH ranging from 7.3 to 7.7. In December 1973, we observed little or no change in the pH compared with the September recordings. The water was more alkaline in March and June 1974 than in previous months. In March 1974, the pH ranged from 7.6 to 8.2;

Table 35

pH OF DUPLICATE WATER SAMPLES

	Survey P (3/73)		Survey 1 (9/73)		Survey 2 (12/73)		Survey 3 (3/74)		Survey 4 (6/74)	
Station	Sample 1	Sample 2	Sample 1	Sample 2	Sample 1	Sample 2	Sample 1	Sample 2	Sample 1	Sample 2
MIS-A	7.7	7.8	7.4	7.3	7.5	7.5	7.7	7.8	7.8	7.8
MIS-B	7.7	7.8	7.5	7.6	7.5	7.4	7.6	7.6	7.8	7.8
CS-A	7.9	7.8	7.7	7.7	7.5	7.5	7.9	7.9	7.9	7.9
CS-B	7.8	7.8	7.5	7.4	7.5	7.5	7.9	8.0	7.8	7.9
ALC	8.0	--	7.6	7.6	7.3	7.4	8.0	8.0	7.8	7.8
OIH	7.7	7.9	7.5	7.5	7.4	7.6	8.0	8.0	7.9	7.8
HP	7.9	7.9	7.4	7.6	7.7	7.7	8.2	8.1	7.9	7.9
SB-A	7.8	7.9	7.5	7.5	7.7	7.8	8.0	8.0	7.9	7.8
SB-B	7.7	7.8	7.5	7.5	6.9	7.5	7.8	7.9	7.8	7.9
RCH-A	7.8	7.8	7.6	7.6	7.8	7.7	8.0	7.9	7.8	7.9
RCH-B	7.8	7.9	7.5	7.6	7.7	7.7	7.9	7.9	7.9	7.9

however, at most stations, the pH was at least 7.9. In June 1974, the pH of the water was almost the same at all stations and ranged from 7.8 to 7.9.

Sediment pH was, in general, lower than water pH, ranging from 6.1 at SB-A in March 1973 to 7.8 at OIH in March 1974, as shown in Table 36. We found relatively large differences in the pH of replicate sediment samples; in one case, the difference was as much as 1.4 pH units, indicating that the chemical characteristics of the sediment, even from the relatively small areas that we sampled, may not be homogeneous.

Table 36

RANGES OF SEDIMENT pH,
FROM THREE TO SEVEN SEDIMENT SAMPLES

Station	Survey P (3/73)	Survey 1 (9/73)	Survey 2 (12/73)	Survey 3 (3/74)	Survey 4 (6/74)
MIS-A	7.0-7.1	6.7-6.9	7.0-7.1	7.0-7.1	7.3-7.5
MIS-B	7.1-7.3	7.0-7.1	7.2-7.3	7.2-7.3	7.1-7.2
CS-A	7.1-7.2	6.4-6.7	6.8-6.9	7.0-7.4	7.0-7.1
CS-B	7.3	6.6-6.8	6.9-7.0	7.0-7.2	7.0-7.2
ALC	7.2-7.9	6.9-7.3	7.0-7.7	7.1-7.4	7.2-7.4
OIH	7.2-7.3	7.1-7.3	7.3-7.4	7.7-7.8	7.3-7.4
HP	7.0-7.4	6.9-7.1	7.0-7.4	7.2-7.3	7.1-7.3
SB-A	6.1-7.5	6.7-7.0	7.1-7.3	7.2-7.5	6.9-7.3
SB-B	7.2-7.4	6.4-7.0	7.3-7.5	7.1-7.5	6.9-7.4
RCH-A	7.3-7.4	6.9-7.1	7.2-7.3	7.5-7.6	7.2-7.4
RCH-B	7.3-8.4	6.9-7.1	7.0-7.3	7.2-7.4	7.0-7.1

Dissolved Oxygen

We measured for dissolved oxygen in water samples only, using a dissolved oxygen meter (YSI, Model 54). All readings were corrected for salinity and an atmospheric pressure of 760 mm Hg. Table 37 presents the mean values for each station.

Throughout the study, corrected dissolved oxygen concentrations were at or near saturation. During any given sampling month, the oxygen content of the water varied by no more than 3.5 mg/liter among stations. As expected, higher dissolved oxygen levels were recorded during the winter, when the water temperature and salinity were low. In March and December 1973 and March 1974, the average dissolved oxygen concentrations for all stations were 8.32, 8.82, and 8.72 mg/liter, respectively. In September 1973 and June 1974, the average was 7.15 and 7.86 mg/liter.

Table 37

MEAN DISSOLVED OXYGEN CONCENTRATIONS OF WATER COLLECTED FROM WITHIN THREE FEET OF BOTTOM AT SELECTED DREDGE AND DISPOSAL AREAS IN SAN FRANCISCO BAY
(Milligrams per Liter)

	Survey				
Station	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)
MIS-A	8.6	8.2	9.6	7.1	8.4
MIS-B	9.0	7.2	9.8	10.1	8.6
CS-A	8.0	7.4	9.4	9.1	8.2
CS-B	8.2	7.4	9.8	9.0	8.4
ALC	7.4	7.7	8.6	8.3	7.8
OIH	7.2	6.9	7.8	8.0	7.8
HP	7.4	7.1	8.0	8.4	8.0
SB-A	8.8	6.8	8.4	9.2	7.5
SB-B	9.0	6.6	9.0	8.9	7.4
RCH-A	9.0	6.8	8.2	9.0	7.1
RCH-B	8.6	6.7	8.2	8.7	7.2

Total Sulfides

Sulfides are produced naturally in aquatic systems through the action of bacteria on organic matter and/or inorganic sulfates under anaerobic conditions. The major product of this action is hydrogen sulfide (H_2S), which dissociates in water to the SH^- and $S^=$ ions. The proportion of H_2S, SH^-, and $S^=$ in water depends on pH. Below pH 10, H_2S and SH^- predominate; and, as pH decreases, the ratio of H_2S to SH^- increases. At pH 5, the compound exists almost entirely as H_2S (McKee and Wolfe, 1963). Under certain conditions, sulfides combine with metal ions to form insoluble metallic sulfides, which can represent a large fraction of the total sulfide content of water or sediment.

Table 38 lists the concentration of total sulfides (H_2S and its ionization products as well as acid-soluble metallic sulfides) of water collected at each station. During each survey, we collected two water samples, both from within 3 ft off the bottom. We found that the sulfide content often varied considerably between duplicate samples. We are not certain whether these differences were real or simply artifacts due to possible improper handling or analysis of the samples. We found even greater differences in the total sulfide content of replicate sediment samples.

The highest sulfide concentration measured was 10 μg/liter in March 1973 for one of the two water samples collected from MIS-A. In general, we encountered higher levels of water sulfides at most stations in March 1973 than in the other sampling periods. Sulfide

Table 38

TOTAL SULFIDE CONTENT OF WATER SAMPLES COLLECTED FROM SELECTED DREDGE AND DISPOSAL AREAS IN SAN FRANCISCO BAY (Micrograms per Liter)

	Survey									
	P (3/73)		1 (9/73)		2 (12/73)		3 (3/74)		4 (6/74)	
	Sample									
Station	1	2	1	2	1	2	1	2	1	2
MIS-A	10.0	4.2	2.1	3.0	4.0	3.5	--	1.8	0	0
MIS-B	6.1	8.6	3.0	2.5	2.5	4.3	0	--	1.1	0
CS-A	2.6	7.3	0.5	0.2	1.9	2.8	1.4	0.2	1.1	1.3
CS-B	7.6	15.0	0.4	0.4	1.9	2.6	0.6	1.6	1.4	0
ALC	2.1	--	0.2	0	5.5	4.4	0.4	0.2	0	0
OIH	0.7	2.4	0.6	0.5	4.1	2.1	0	--	0	0
HP	2.7	2.3	0	0.8	0.6	--	1.8	0.4	0	0
SB-A	2.8	3.2	2.8	3.2	1.5	2.7	0.3	1.5	0	0
SB-B	3.3	4.4	1.4	1.7	1.1	1.3	0.5	0.5	0	0
RCH-A	4.9	6.3	1.9	3.5	3.4	1.5	0	0	0	0
RCH-B	3.7	2.2	4.2	2.5	3.5	4.9	0	0	0	0

levels generally decreased in September 1973 and slightly increased in December 1973. Most conspicuous, however, were the very low sulfide concentrations found at all stations in March and June 1974. Table 38 shows these general trends.

In the presence of oxygen, sulfides are oxidized readily (Sverdrup et al., 1942). Although the amounts of sulfides in our water samples were relatively low, we should not have found any because of the high levels of dissolved oxygen in the samples (see Table 37). The sulfide and dissolved oxygen analyses were performed properly, so sulfides possibly were generated during some stage between sample collection and sample analysis.

Sediment sulfide concentrations were determined on three to seven sediment samples per station per survey. Table 39 presents the averages and standard deviations for each station. At many stations, the measured levels of total sulfide varied considerably. In some instances, we could predict the occurrence of differences by noting differences in the color of the sediment samples as they were collected. As we expected, the samples with more darkly colored material contained more sulfides than the samples with a high proportion of lightly colored material.

In general, the sediment from stations south of and including OIH contained a greater amount of sulfides than the sediment collected from stations to the north. At the southern stations, we observed no consistent relationship between the sulfide content of sediment collected from the dredged areas and from the dredged-material disposal areas. However, we found that the sulfide concentration of sediment from OIH was consistently high, ranging from an average of 442 mg/kg to 730 mg/kg; whereas at HP, at the stations located at the South Bay disposal site, and at the Redwood City Harbor entrance channel, the sediment sulfide content fluctuated markedly from sampling period to sampling period.

At MIS-A and at CS-A--sites where considerable dredging and disposal of dredged material occur--the average sulfide content of sediment ranged from 0 to 18 mg/kg* and from 10 to 313 mg/kg,

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*The zero value may be an artifact.

Table 39

AVERAGE TOTAL SULFIDE CONCENTRATIONS OF SEDIMENT COLLECTED FROM SELECTED DREDGE AND DISPOSAL AREAS IN SAN FRANCISCO BAY
One Standard Deviation in Parentheses*
(Milligrams per Kilogram Wet Weight)

	Survey				
Station	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)
MIS-A	2 (1)	18 (14)	2 (5)	16 (9)	0 (0)
MIS-B	17 (34)	172 (42)	80 (52)	61 (3)	8 (3)
CS-A	123 (71)	313 (79)	124 (84)	10 (14)	219 (192)
CS-B	1 (1)	191 (95)	73 (83)	121 (88)	315 (7)
ALC	60 (69)	6 (7)	71 (82)	76 (44)	3 (1)
OIH	442 (264)	527 (149)	488 (89)	570 (26)	730 (134)
HP	370 (16)	63 (46)	208 (72)	257 (122)	71 (19)
SB-A	365 (156)	148 (54)	151 (60)	600 (270)	313 (136)
SB-B	278 (34)	545 (52)	77 (14)	490 (277)	443 (108)
RCH-A	261 (43)	148 (25)	237 (39)	183 (166)	373 (86)
RCH-B	173 (79)	535 (110)	628 (318)	125 (19)	113 (21)

*Rounded to nearest whole number.

The sediment from CS-A containe. nsiderably more sulfide than the sediment from MIS-A except in March 1974, when the sulfide content of the sediment from both stations was about the same. The March 1974 sampling occurred at a time of intensive dredging activity at Mare Island Strait, and most of the dredged material was taken to the Carquinez Strait disposal site.

Sediment from the undredged area of Mare Island Strait, MIS-B, contained a higher level of sulfides than sediment from MIS-A during all sampling periods. The sulfide content of sediment

collected from the center of the disposal site, CS-A, was greater than that of the sediment collected from the presumably less disturbed area near the northern edge of the disposal site (CS-B) only during the 1973 sampling months.

Of all disposal areas studied, ALC contained the lowest average amount of sediment sulfide.

Heavy Metals

During each survey of each station, we took one subsample from each of three to five replicate sediment samples and analyzed them for copper, cadmium, lead, zinc, and mercury--the metals of greatest interest to the Corps of Engineers, San Francisco District. We did not analyze the sediment for zinc or mercury during the March and September 1973 surveys, nor did we determine the sediment concentrations of any of the metals in samples collected from SB-A or from RCH-A.

Generally, the relative abundance of the five metals followed the order zinc > copper > lead > cadmium > mercury. The average concentration of zinc ranged from 69 mg/kg dry weight to 239 mg/kg. The range for copper was 12 to about 98 mg/kg. Ranges for lead, cadmium, and mercury were 10 to 81 mg/kg, 0.77 to 2.61 mg/kg, and 0.02 to 0.44 mg/kg, respectively. On an area-by-area basis, we compared the range of average concentrations of each metal as measured in our study with those obtained by other investigators and found ours to be similar to those of others. Table 40 presents these data.

Table 41 shows the mean concentration of each metal by station and survey. At most stations, we did not observe any general pattern to the fluctuations in heavy-metal content of the sediment. However, we did find some interesting trends at the stations in Mare Island Strait and the Carquinez Strait disposal site.

Comparison of the average values presented for each metal in Table 40 shows that, although the concentrations of the metals fluctuated with the time of sampling, little difference existed

Table 40

HEAVY-METAL CONCENTRATIONS OF SEDIMENT IN SAN FRANCISCO BAY
(Milligrams per Kilogram Dry Weight)

Location	Copper	Cadmium	Lead	Zinc	Mercury	Reference
Mare Island Strait	44-66	0.71-2.1	22-47	97-175	0.016-0.44	Present study[1]
	80-99	1.2-3.0	36-55	140-163	0.45-0.49	Anderlini et al., 1974[2]
	117	0.61	51	171	0.64	Battelle Northwest Laboratories, 1974[3]
	70	--	100	--	0.64	Peterson et al., 1972
Carquinez Strait	22-98	0.77-2.1	19-52	82-152	0.017-0.39	Present study[1]
	30	--	20	--	0.06	Peterson et al., 1972
Alcatraz	12-35	0.95-1.7	13-47	69-90	0.054-0.10	Present study[1]
	5	--	10	--	0.08	Peterson et al., 1972
Oakland Inner Harbor	28-90	0.90-2.6	35-81	115-239	0.018-0.36	Present study[1]
	166	1.3	117	222	1.6	Battelle Northwest Laboratories, 1974[3]
	--	--	14-136	41-274	0.1-0.3	Lee and Plumb, 1974[4]
	50	--	70	--	0.44	Peterson et al., 1972
Hunters Point	42-71	1.0-1.4	41-51	136-158	0.28-0.34	Present study[1]
	5-50	--	None	--	0.08-0.19	Peterson et al., 1972[5]
South bay area	29-52	0.78-[illegible]	22-32	81-126	0.23-0.39	Present study[1]
	30-50	--	30-50	--	0.23-1.0	Peterson et al., 1972
Redwood City Harbor	35-57	0.88-1.4	28-46	107-148	0.03-0.37	Present study[1]
Redwood Creek (mouth)	95	0.89	49	176	0.63	Battelle Northwest Laboratories, 1974[3]
Redwood Creek	100-150	--	70-200	--	0.25-0.54	Peterson et al., 1972

[1]Means for 3-4 samples at one station; 3-5 surveys conducted between March 1973 and June 1974.

[2]Means for 6-13 stations; nine surveys conducted between October 1973 and April 1974.

[3]Mean for 2 core samples (cadmium values are tentative).

[4]Range of values obtained for several locations.

[5]Range of values for sediment collected immediately north of SRI station.

Results and Discussion
Physical and Chemical Characteristics
Heavy Metals

Table 41

MEAN HEAVY-METAL CONCENTRATIONS IN SEDIMENT
Standard Deviation in Parentheses
(Milligrams per Kilogram Dry Weight)

Survey	Station								
	MIS-A	MIS-B	CS-A	CS-B	ALC	OIH	HP	SB-B	RCH-B
P (March 1973)									
Copper	49.6 (7.9)	57.0 (5.1)	98.2 (13.3)	74.3 (9.2)	35.4 (17.2)	89.8 (10.6)	71.4 (6.5)	51.6 (7.9)	53.8 (5.4)
Cadmium	0.98 (0.09)	0.99 (0.11)	1.69 (0.36)	2.11 (0.26)	1.72 (0.21)	2.44 (0.22)	1.38 (0.12)	0.96 (0.17)	1.01 (0.22)
Lead	22.4 (1.5)	22.6 (2.3)	42.8 (5.8)	35.1 (4.6)	47.3 (0.80)	77.1 (5.7)	44.6 (5.3)	29.0 (3.6)	27.6 (6.0)
1 (Sept. 1973)									
Copper	60.3 (13.3)	61.4 (7.5)	94.8 (7.3)	95.3 (17.1)	16.9 (1.5)	89.1 (33.0)	55.3 (5.8)	41.9 (5.5)	56.6 (10.1)
Cadmium	0.86 (0.19)	1.00 (0.06)	1.94 (0.17)	1.81 (0.38)	1.40 (0.11)	2.61 (0.51)	1.22 (0.14)	1.21 (0.26)	1.25 (0.23)
Lead	26.1 (8.2)	28.4 (3.3)	50.4 (0.30)	51.9 (26.2)	34.3 (6.4)	76.3 (15.8)	48.1 (15.7)	25.1 (3.1)	40.4 (6.5)
2 (Dec. 1973)									
Copper	47.7 (25.6)	44.0 (11.3)	54.7 (7.2)	39.0 (1.0)	23.0 (9.2)	28.3 (3.5)	42.3 (12.7)	39.7 (16.5)	35.0 (7.8)
Cadmium	0.99 (0.38)	0.71 (0.14)	1.27 (0.49)	1.07 (0.20)	0.97 (0.50)	0.89 (0.16)	1.01 (0.24)	0.78 (0.19)	1.03 (0.24)
Lead	26.7 (10.3)	26.0 (3.0)	40.0 (8.5)	30.0 (4.6)	13.0 (7.3)	35.0 (6.0)	40.7 (6.5)	31.7 (6.8)	40.0 (6.0)
Zinc	107.0 (62.1)	118.3 (35.0)	142.0 (15.7)	112.0 (5.0)	77.3 (17.6)	115.0 (13.1)	145.0 (18.7)	125.7 (32.9)	130.0 (7.0)
Mercury	0.32 (0.11)	0.44 (0.31)	0.39 (0.08)	0.26 (0.03)	0.07 (0.01)	0.36 (0.04)	0.28 (0.12)	0.39 (0.15)	0.22 (0.14)
3 (March 1974)									
Copper	65.7 (16.4)	64.0 (4.4)	21.7 (8.1)	39.0 (6.2)	31.0 (1.7)	33.0 (12.2)	49.7 (1.5)	29.0 (1.7)	43.0 (13.1)
Cadmium	2.07 (0.32)	1.67 (0.06)	0.77 (0.06)	0.93 (0.04)	1.23 (0.06)	1.23 (0.15)	1.25 (0.27)	1.03 (0.39)	1.40 (0.43)
Lead	40.7 (4.2)	47.3 (8.1)	19.0 (1.0)	29.3 (1.2)	25.0 (1.0)	48.3 (3.5)	43.3 (6.4)	31.8 (13.1)	46.0 (7.0)
Zinc	175.3 (16.8)	166.3 (2.5)	82.0 (9.5)	109.3 (11.0)	89.7 (8.5)	126.3 (24.2)	136.0 (5.3)	99.7 (13.6)	148.0 (7.0)
Mercury	0.14 (0.03)	0.27 (0.05)	0.02 (0.01)	0.16 (0.18)	0.10 (0.03)	0.30 (0.24)	--	0.23 (0.20)	0.03 (0.03)

Table 41 (Concluded)

Survey	MIS-A	MIS-B	CS-A	CS-B	ALC	OIH	HP	SB-B	RCH-B
4 (June 1974)									
Copper	49.7	49.0	66.3	56.3	12.0	83.7	57.7	30.7	42.3
	(2.1)	(3.5)	(11.0)	(3.1)	(1.0)	(21.7)	(15.0)	(11.2)	(4.7)
Cadmium	0.77	0.83	1.43	1.15	0.95	2.20	1.24	0.81	0.88
	(0.03)	(0.13)	(0.06)	(0.23)	(0.13)	(0.78)	(0.39)	(0.20)	(0.02)
Lead	24.0	22.0	34.0	42.0	33.7	81.0	51.3	22.0	32.3
	(1.0)	(2.6)	(4.6)	(9.8)	(5.7)	(18.4)	(18.1)	(6.0)	(2.5)
Zinc	106.0	97.0	151.7	145.7	69.0	238.7	157.7	81.0	107.0
	(13.5)	(12.8)	(30.7)	(2.9)	(10.1)	(57.0)	(46.3)	(30.8)	(15.1)
Mercury	0.02	0.03	0.21	0.20	0.05	0.02	0.34	0.38	0.37
	(0.03)	(0.05)	(0.36)	(0.21)	(0.07)	(0.03)	(0.42)	(0.36)	(0.53)

between the concentration of a given metal during a given sampling period at MIS-A in the dredged ship channel and MIS-B in the undredged portion of Mare Island Strait. In March 1973, September 1973, and June 1974, we found the same to be true at the disturbed area (CS-A) and at the undisturbed area (CS-B) of the Carquinez Strait disposal site. However, in December 1973, we found noticeably higher concentrations of copper, cadmium, and zinc at CS-A than at CS-B; and, in March 1974, the concentrations of all five metals were noticeably higher at CS-B than at CS-A.

In the dredged area of Mare Island Strait (MIS-A), the average concentration of all metals was lower than in the center of the Carquinez Strait disposal site (CS-A) during all sampling months except March 1974. In March 1974, the average concentration of all metals, except mercury, were significantly higher ($p = 0.05$) at MIS-A than at CS-A. Although we did not test for significance, we found that, in March 1974, the concentration of all heavy metals at both stations in Mare Island Strait were higher than the concentration at the two stations in the Carquinez Strait disposal site and that the trend was just the opposite during the other four sampling months.

The high levels of heavy metals found in the Mare Island Strait sediments in March 1974 may have resulted from storm water runoff from cities along the shore of Mare Island Strait and along the

lower reaches of the Napa River. The estimated amounts of copper, lead, and zinc washed off annually from the streets of the City of Vallejo, located along the eastern shore of Mare Island Strait, are 1,900, 43,000, and 8,700 lb, respectively (URS Research Company, 1974). During March 1974, precipitation in the Mare Island Strait area amount to at least 5 in. (Anderlini et al., 1974).

Turbidity

As stated in "Study Approach," the optical instrument we used to measure turbidity did not meet the requirements of a true nephelometer; hence, whereas the data are presented in nephelometric units (NU), they cannot be compared with turbidity values obtained by other investigators using a true nephelometer. However, the data are of value in comparing the relative turbidity between the stations and between the sampling periods used in this study.

Although the standard method for estimating turbidity is use of the Jackson candle turbidometer, this procedure does not permit direct estimation of turbidity less than 25 Jackson turbidity units (JTU); it is best suited for work with highly turbid water. The nephelometric method has a wider working range, precision, and sensitivity (APHA, 1971).

Throughout the study, we often found considerable disagreement in the turbidity readings of the replicate water samples and attribute this problem to our method of collecting the samples. To minimize drift of the van Dorn sampler during sample collection and to fix the depth of sample collection, we attached a heavy concrete weight to the sampler. This weight extended about 2 ft below the sampler and was lowered to the bottom before the sampler trigger mechanism was released. The presence of the weight on the soft sediment encountered at most stations may have disturbed the sediment enough to cause contamination of the sample.

We estimated the turbidity of two water samples per station, and Table 42 presents the results. During the preliminary survey, we did not measure turbidity above 500 NU.

Table 42

TURBIDITY OF WATER COLLECTED FROM SELECTED DREDGE AND DISPOSAL AREAS IN SAN FRANCISCO BAY
Values Are Given in Nephelometric Units (NU)

Station	P (3/73) 1	P (3/73) 2	1 (9/73) 1	1 (9/73) 2	2 (12/73) 1	2 (12/73) 2	3 (3/74) 1	3 (3/74) 2	4 (6/74) 1	4 (6/74) 2
MIS-A	450	65	100	120	190	110	37,500	10,000	85	70
MIS-B	130	65	100	85	65	95	500	500	60	30
CS-A	240	85	21	15	130	150	160	130	120	150
CS-B	>500	>500	10	10	110	120	100	140	390	260
ALC	11	--	5	5	24	23	5	10	11	12
OIH	2	3	6	5	24	24	18	18	35	37
HP	5	2	8	6	7	12	45	45	35	35
SB-A	14	11	2	2	7	7	45	40	11	13
SB-B	10	9	1	2	2	1	23	34	--	10
RCH-A	11	17	2	1	7	6	33	33	40	40
RCH-B	11	11	5	5	7	7	14	21	28	17

On the average, the water at Mare Island Strait and Carquinez Strait was much more turbid than water from other areas. At MIS-A, the average turbidity ranged from 78 NU in June 1974 to 23,750 NU in March 1974. In Mare Island Strait the extremely turbid water observed in March 1974 coincided with heavy dredging activity and high rainfall. The turbidity of the water at MIS-B, located in an undredged area east of MIS-A, was lower than at MIS-A during the same sampling months.

Results and Discussion
Physical and Chemical Characteristics
Turbidity

Monthly turbidity averages ranged from 45 NU in June 1974 to 500 NU in March 1974 at MIS-B. Although turbidity at MIS-B also rose markedly in March 1974, the lower turbidity reading indicates that water from the ship channel does not mix readily with water outside the channel. However, some of the difference may have resulted from greater disturbance by taking the water samples near a soft, recently dredged bottom than near the more consolidated sediments of an undredged bottom.

At Carquinez Strait, average monthly turbidity values ranged from 18 to 162 NU at CS-A and from 10 to at least 500 NU at CS-B. The water was least turbid in September 1973, and, during the other sampling months, turbidity did not vary much at CS-A but fluctuated considerably at CS-B.

Although water from Mare Island Strait enters Carquinez Strait we did not observe any evidence at the Carquinez Strait stations of the highly turbid conditions in Mare Island Strait in March 1974. In fact, at both Carquinez Strait stations, the water in March 1974 was about as turbid as in December 1973.

Turbidity at the Alcatraz disposal site did not vary as much seasonally as at other areas. Average monthly turbidity values ranged from 5 to 24 NU. Water in this area was least turbid in September and most turbid in December. According to information provided by the U.S. Army Corps of Engineers and the Dredging Contractors Association, the Alcatraz disposal site is used throughout the year. However, during our field surveys, we did not observe any disposal activity in the area. Dredged material transferred to the site appears to disperse rapidly. Hence, determining the degree of turbidity created in the area by disposal activity would require sampling at the time of disposal or very shortly thereafter.

At OIH, turbidity increased from an average 2.5 NU in March 1973 to 24 NU in December. In March 1974, turbidity decreased slightly (to 18 NU) and then increased to 36 NU in June. Information provided by the Dredging Contractors Association shows that Oakland Inner Harbor is dredged frequently. Although we could not obtain information on the exact dredging dates and sections that

were dredged during the study period, we did obtain project record information indicating that dredging occurred during every month between July 1973 and November 1974.

Between March 1973 and March 1974, the average turbidity at station HP in the Hunters Point disposal site increased from 4 NU to 45 NU, then decreased to 35 NU in June. Fluctuation in turbidity at this station probably is influenced most by wind and wave action as well as land runoff. We have no records of official use of the Hunters Point disposal area during the study period.

Seasonal fluctuations in turbidity at the stations located at the southern portion of San Francisco Bay followed similar patterns. In general, the water was least turbid in September. Highest turbidities at SB-A and SB-B occurred in March 1974 and in June 1974 at RCH-A and RCH-B. At all these stations, the mean turbidity values were much higher in March 1974 than in March 1973.

Sediment Grain Size

In the preliminary survey, we used a different method of determining grain-size distribution than in the subsequent surveys, and we did not categorize the sizes as extensively. We have chosen not to present the preliminary data graphically because a sufficient number of data points is lacking to describe properly the distribution. We have, however, tabulated these data. The tabulated sand, silt, and clay categories for preliminary data are not based on the same grain-size groupings as the data obtained in subsequent surveys. According to the Wentworth scale of particle size classification (Holme and McIntyre, 1971), sand consists of particles measuring from 63 to 2,000 μ in diameter. Particles measuring from 4 to 62 μ in diameter are classified as silt, and those measuring less than 4 μ in diameter are called clay. This scheme was used to classify the sediment obtained in the preliminary survey into the sand, silt, and clay categories. In the surveys that followed, the smallest grain size considered was 5 μ. Although this size of particle is classified as silt, we have elected to consider all particles less than 5 μ as clay. In the last four surveys, we did not determine specifically the percentage of the sample less than 62 μ, the sand-silt boundary. Instead, the largest

silt particle measured was 43 μ. Because of this, we chose to classify all particles larger than 5 μ but smaller than 43 μ as silt and all particles 125 μ or larger in diameter as sand.

During this investigation, we found the sediment at both Mare Island Strait stations to be composed primarily of silt and clay, as shown in Table 43. Together, these fractions comprised at least 90% of the total dry sample weight. The proportion of silt and clay varied from month to month, and ranged from 1:0.07 to 1:1.69 (silt:clay) at MIS-A. The differences in the grain-size distribution curves shown in Figure 5 are due primarily to changes in the silt-to-clay ratio.

Usually, the sediment at MIS-A had less silt than clay. In March 1973, the sediment contained approximately the same amount of silt and clay. The most marked change in the silt-to-clay ratio occurred in December, when the sediment consisted of 90% silt and 6.3% clay. A large rise in the December silt fraction also was observed at MIS-B, where in all other months the sediment contained from 1.1 to 1.53 times more clay than silt (Table 43). Figure 6 shows clearly this shift.

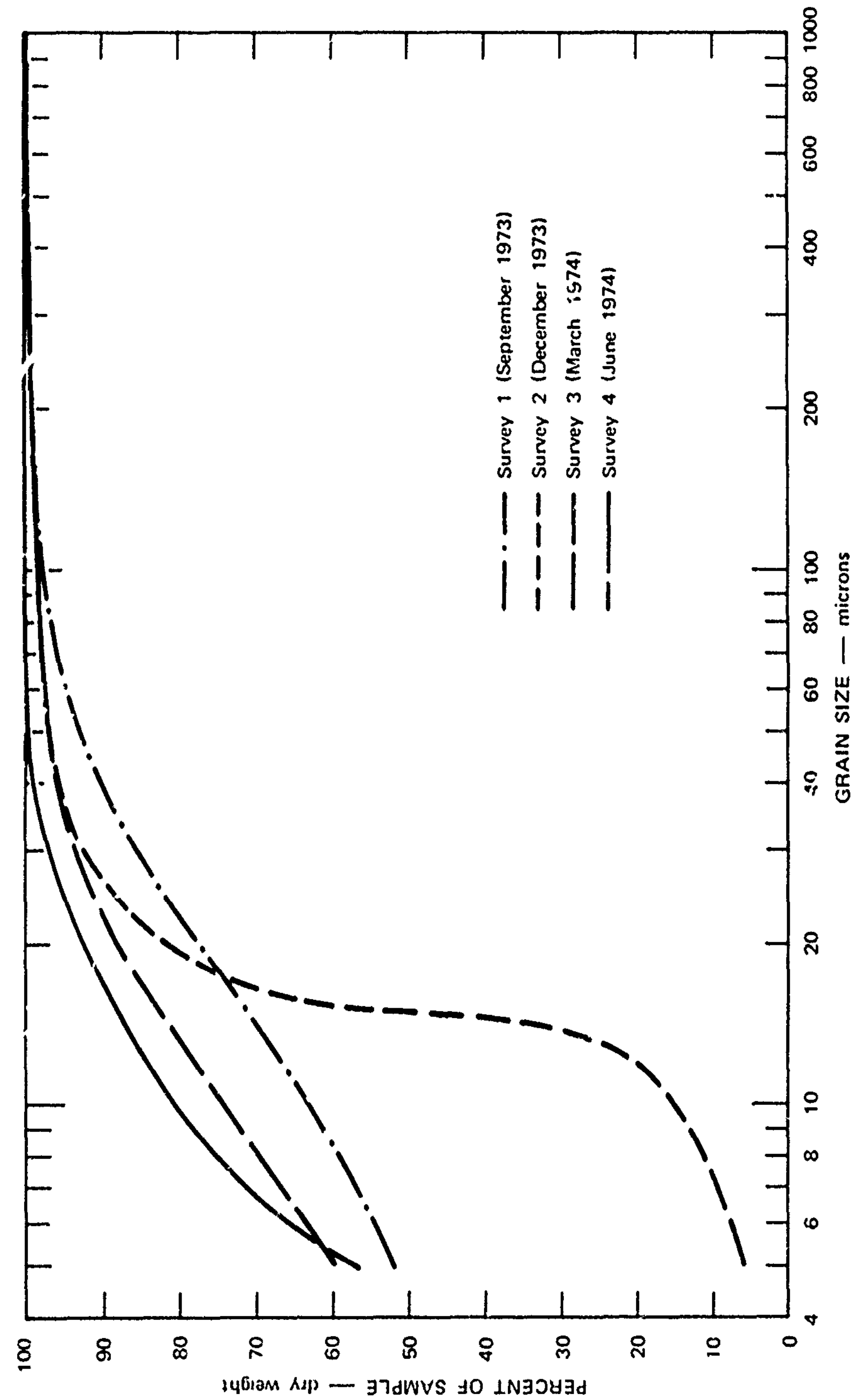
The sediment from the stations in Carquinez Strait contained a much larger proportion of sand than the sediment from Mare Island Strait (Table 43). We were interested especially in the March 1974 grain-size distribution at Station CS-A because of the large amount of sediment that was transferred to the Carquinez Strait disposal site from Mare Island Strait during that period. We found the sediment from the two areas to have considerably different grain-size distributions (Figures 5 and 7). Whereas the sediment at MIS-A was composed of 96.8% silt and clay, the sediment at CS-A contained only 22.1% silt and clay and a large (77.9%) amount of sand. The amount of sand in the March 1974 sediment was about 4.2 times the average for the other four sampling months.

We found the March 1974 silt-to-clay ratios for sediment from MIS-A and CS-A to be quite similar--1:1.69 for MIS-A and 1:1.63 for CS-A; we also found a similarity in the ratios in March 1973 and in December 1973. A transfer of sediment from Mare Island Strait to Carquinez Strait occurred in February and November 1973. About 845,000 yd^3 was transferred in November, and we do not know how

Table 43

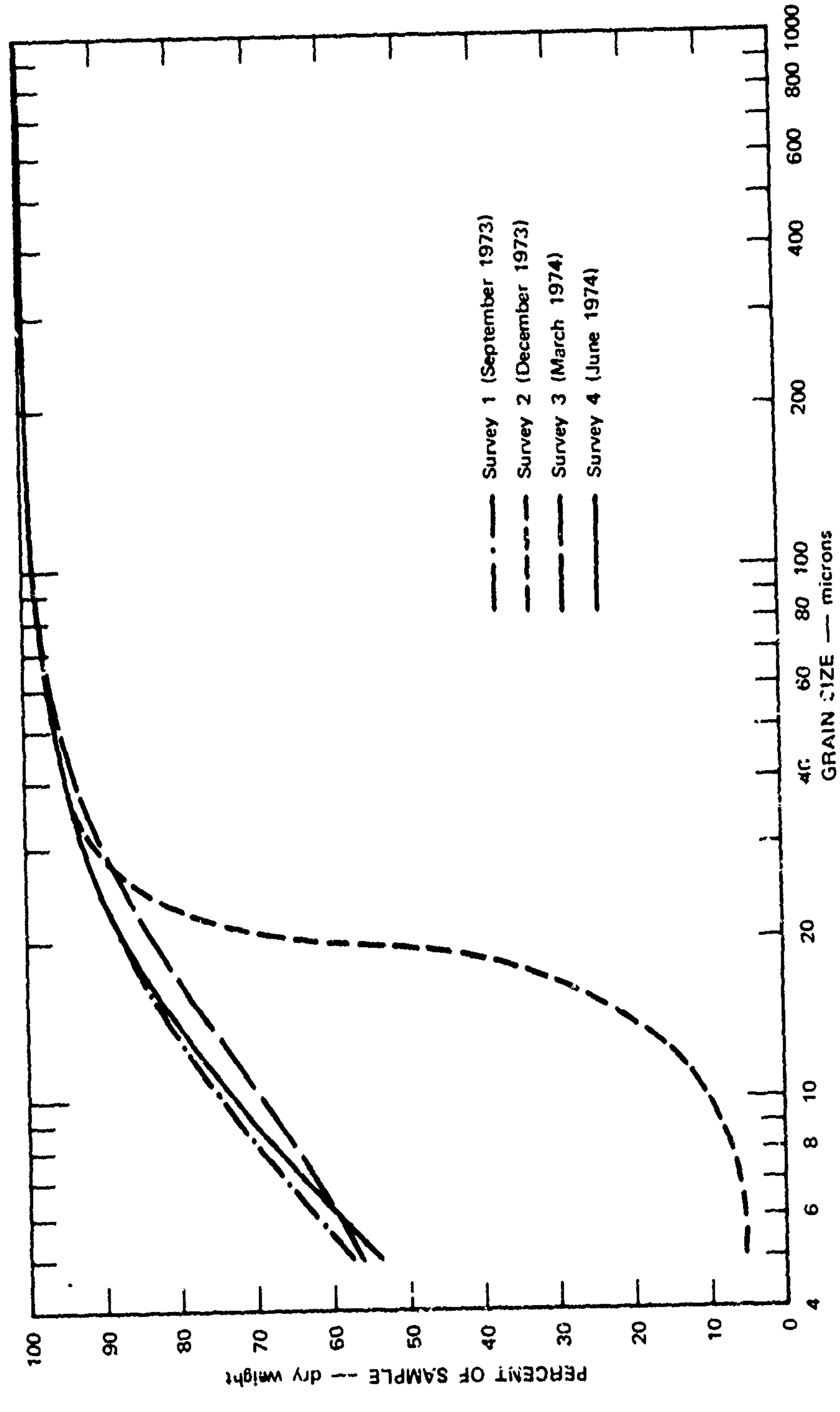
PROPORTION OF SAND, SILT, AND CLAY IN SEDIMENT
FROM STATIONS AT MARE ISLAND STRAIT AND CARQUINEZ STRAIT

Survey	Date	Percent Sand	Percent Silt	Percent Clay	Silt:Clay Ratio
MIS-A					
P	3/73	2.8%	48.9%	48.3%	1:0.99
1	9/73	8.0	41.7	50.3	1:1.21
2	12/73	3.7	90.0	6.3	1:0.07
3	3/74	3.2	36.0	60.8	1:1.69
4	6/74	1.2	42.2	56.6	1:1.34
MIS-B					
P	3/73	3.0	46.3	50.7	1:1.11
1	9/73	3.8	38.0	58.2	1:1.53
2	12/73	5.1	90.1	4.8	1:0.05
3	3/74	5.8	38.4	55.0	1:1.45
4	6/74	3.0	43.0	54.0	1:1.25
CS-A					
P	3/73	8.1	46.9	45.0	1:0.96
1	9/73	18.7	32.5	48.8	1:1.50
2	12/73	12.4	79.7	7.9	1:0.099
3	3/74	77.9	8.4	13.7	1:1.63
4	6/74	34.1	25.3	40.6	1:1.60
CS-B					
P	3/73	79.9	9.8	10.3	1:1.05
1	9/73	47.8	23.2	29.0	1:1.25
2	12/73	34.8	63.1	2.1	1:0.03
3	3/74	51.8	17.8	30.4	1:1.70
4	6/74	52.2	18.3	29.5	1:1.61



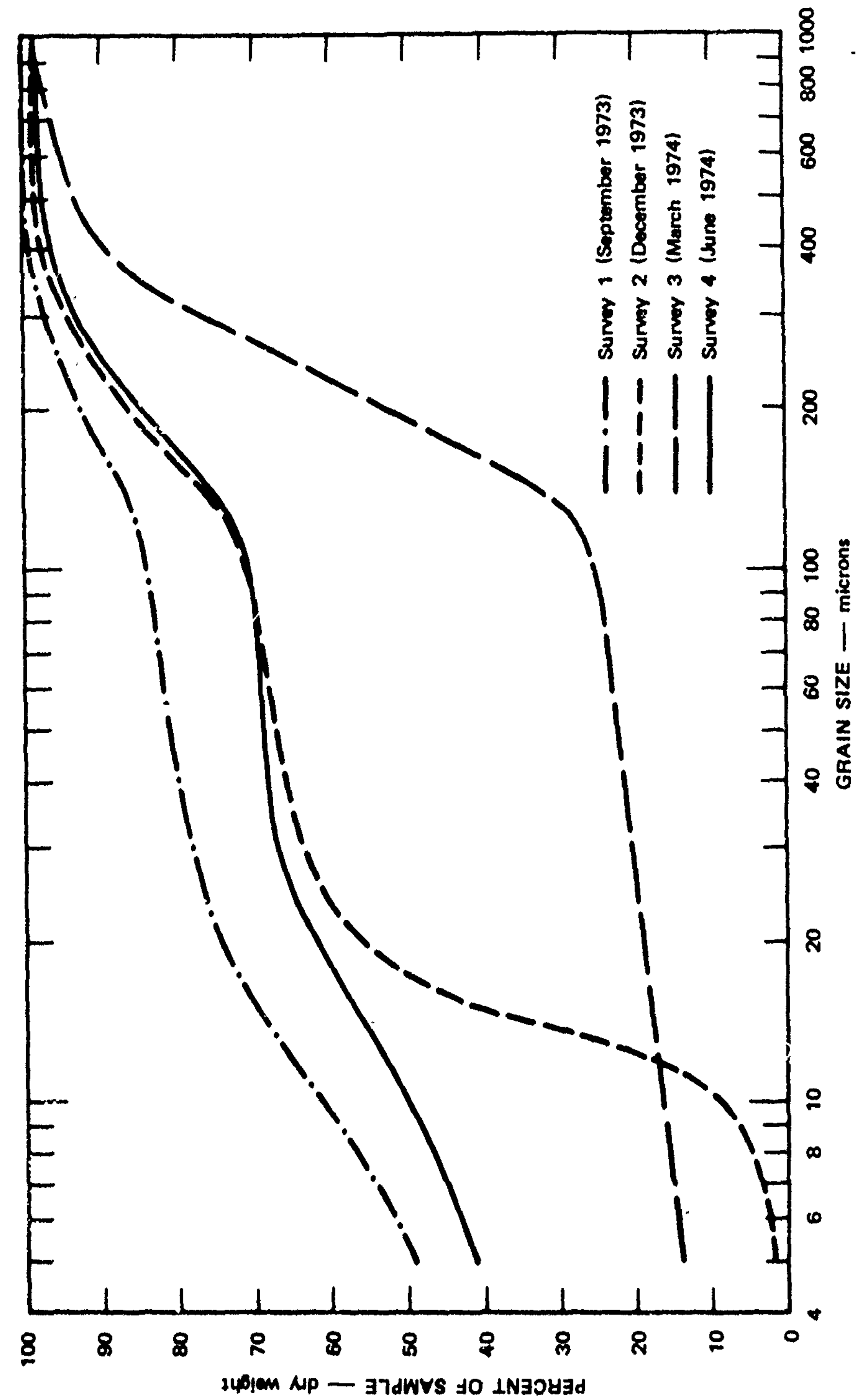
*Plotted values are means derived from three samples, and represent percent of sample less than the indicated grain size.

FIGURE 5 SEDIMENT GRAIN-SIZE DISTRIBUTION FOR STATION MIS-A*



*Plotted values are means derived from three samples, and represent percent of sample less than the measured grain size.

FIGURE 6 SEDIMENT GRAIN-SIZE DISTRIBUTION FOR STATION MIS-B*



*Plotted values are means derived from three samples, and represent percent of sample less than the measured grain size.

FIGURE 7 SEDIMENT GRAIN-SIZE DISTRIBUTION FOR STATION CS-A*

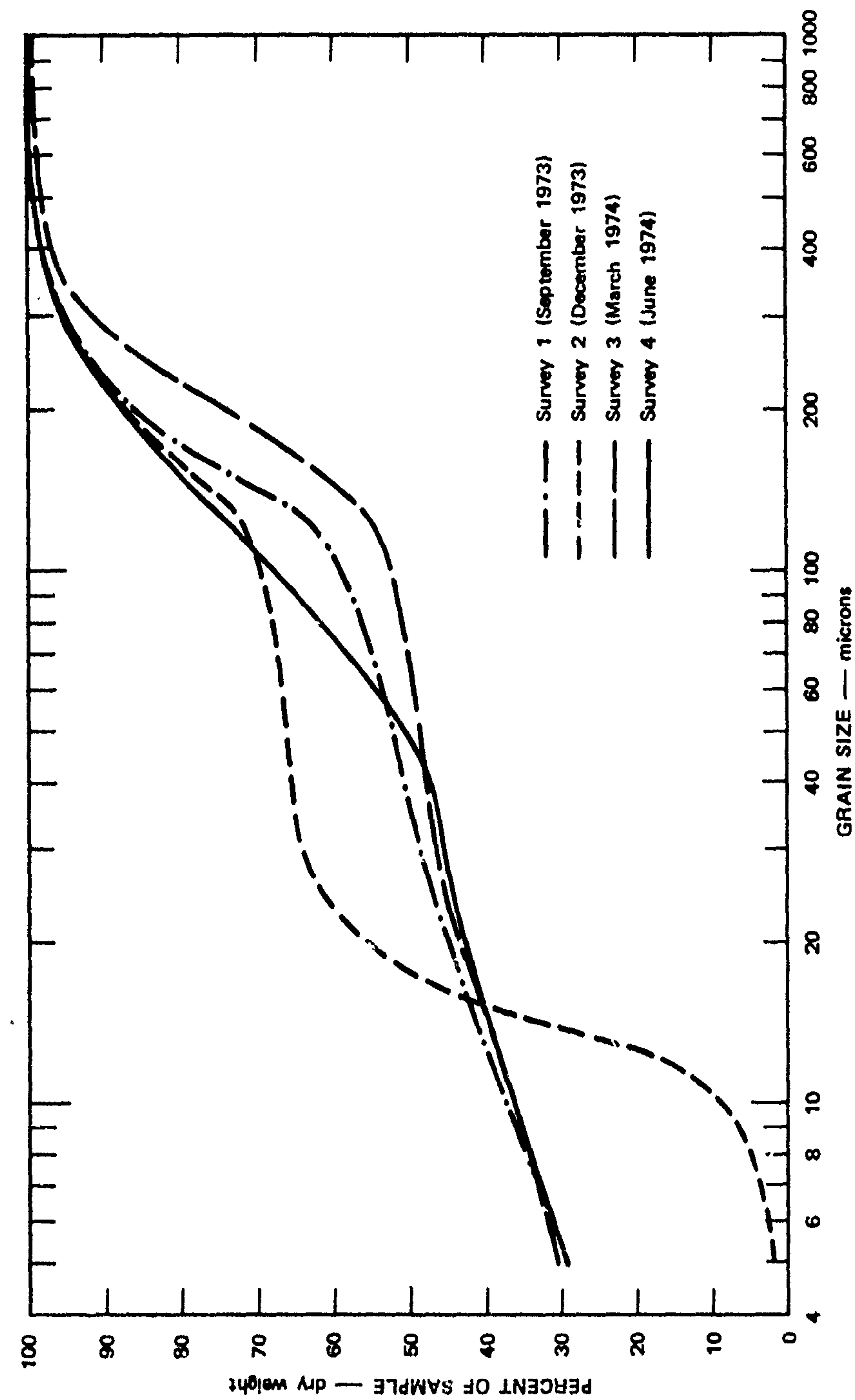
much was transferred in February. Although the similarity in the ratios suggests that the sediment in both areas was of the same origin, the similarity could have been a coincidence.

Although the sediment from Carquinez Strait was sandier than that from Mare Island Strait, the proportion of sand at CS-A during the month of active sediment transfer was about 4.2 times greater than the average for the other four months. Although we have no direct evidence, we believe that sand from Mare Island Strait may account for the difference. This sand, because of its greater density, has a greater chance of being deposited on the bottom than the lighter silt and clay.

The large increase in the proportion of silt, observed in December at MIS-A and MIS-B, also was observed at CS-A and CS-B (Figures 7 and 8). This increase in the silt fraction was noticeable in the color of the sediment (in December, it contained a larger amount of tan fines than in other months). We believe that that the tan material represented fresh silt washed into the Mare Island and Carquinez strait areas by the Napa and the Sacramento-San Joaquin Rivers.

The sediment from the Alcatraz disposal area was composed almost entirely of sand during September 1973 and June 1974 and almost entirely of silt and clay during December 1973 and March 1974. Table 44 and Figure 9 present these data. We also found a high proportion of sand in the sediment collected during March 1973; however, this sediment was collected from an area near deepest (160 ft) area of the disposal site. In December 1973, the sediment was very silty, containing 81% silt and only 3.7% clay. In March 1974, the sediment contained less silt than clay, but the difference between these two fractions was much less than in December.

Sediment from OIH also contained a considerable amount of sand (Table 44, Figure 10). The five-survey average was 65.5% sand, and the range was 55.1% to 72.3%. In September 1973 and March and June 1974, the sediment contained less silt than clay. During these months, the sediment was composed of an average of 16.5% silt and 21.6% clay. In March and December 1973, however, about nine times more silt than clay was in the sediment.



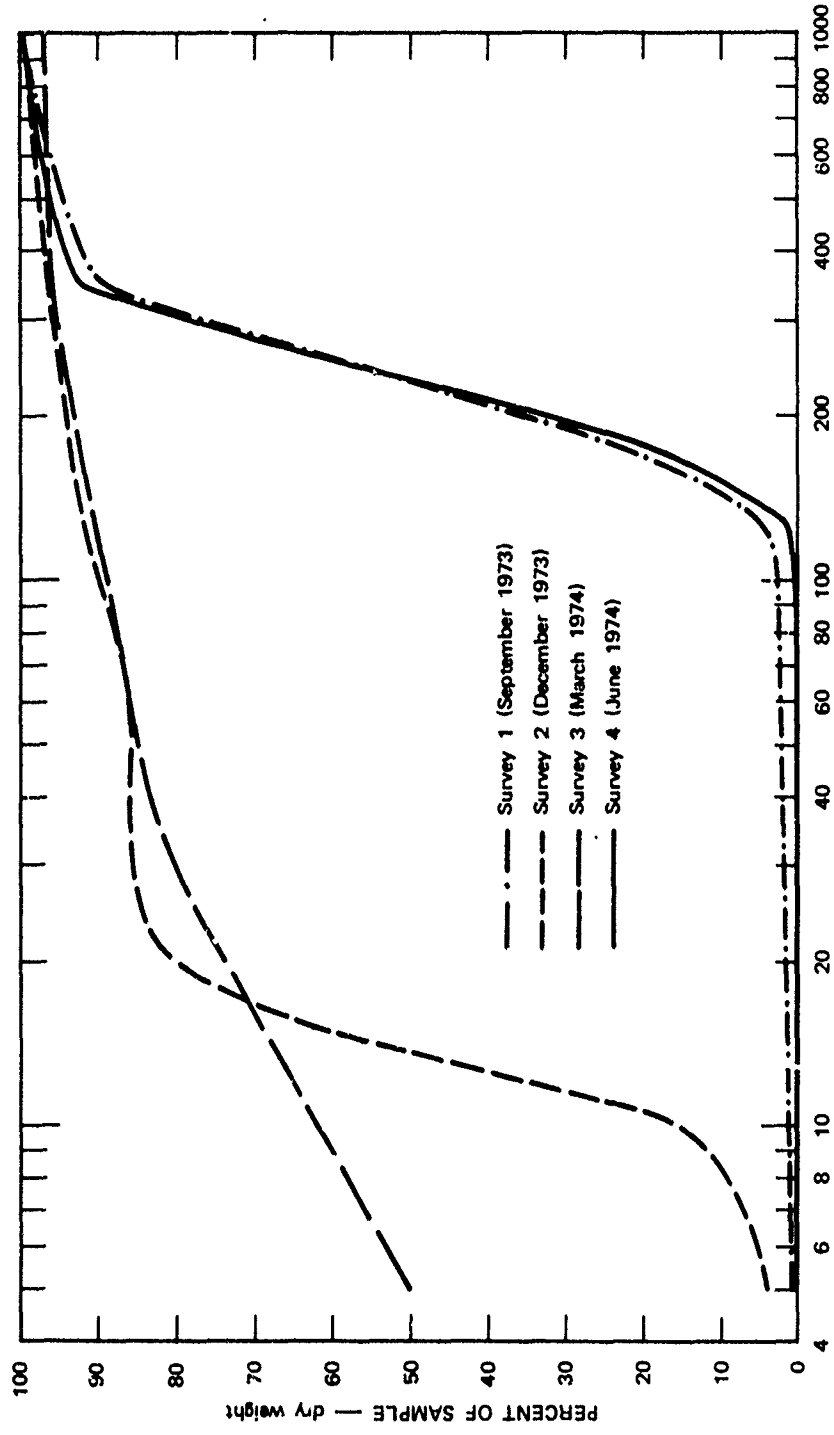
*Plotted values are means derived from three samples, and represent percent of sample less than the measured grain size.

FIGURE 8 SEDIMENT GRAIN-SIZE DISTRIBUTION FOR STATION CS-B*

Table 44

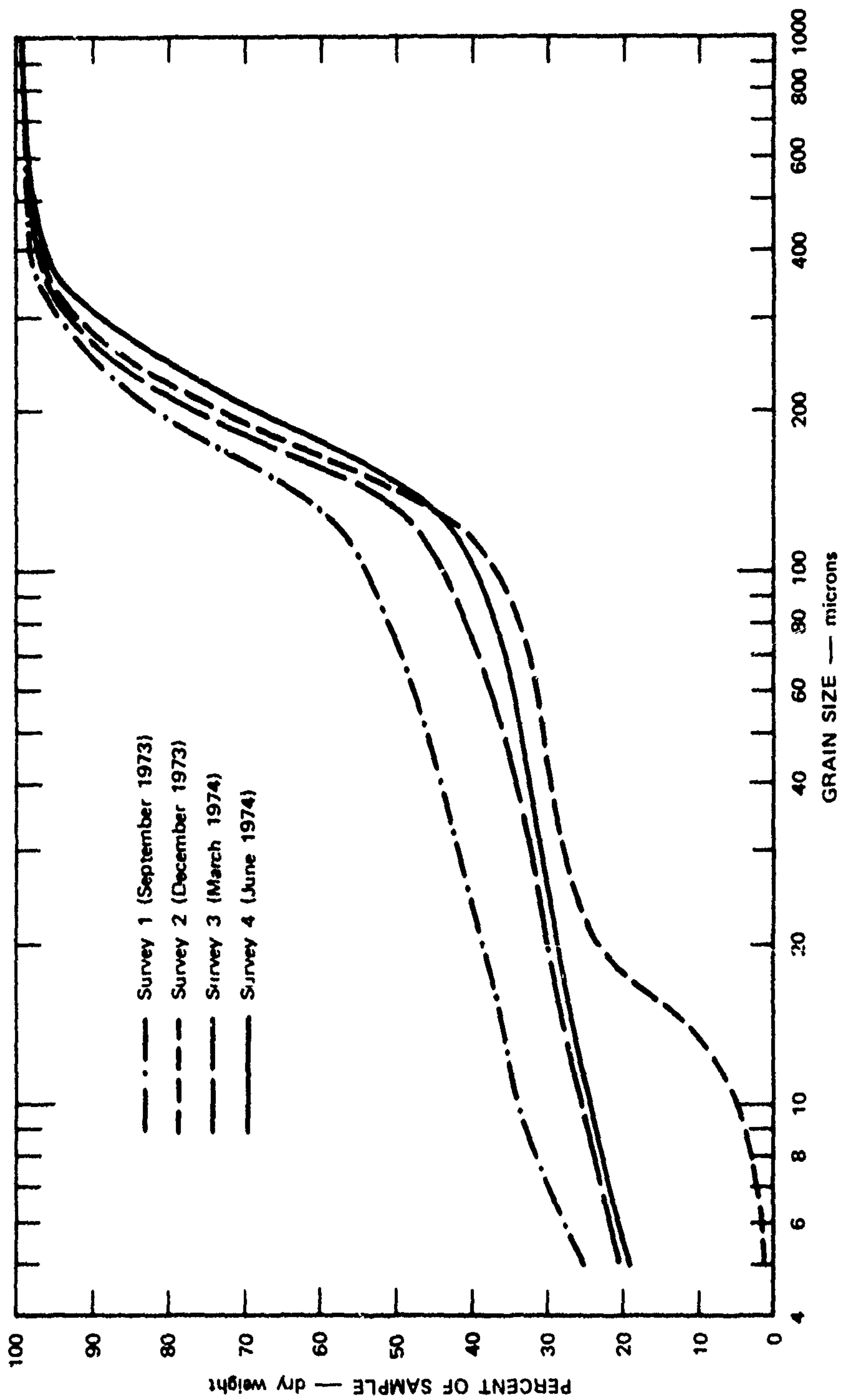
PROPORTION OF SAND, SILT, AND CLAY IN SEDIMENT
OF CENTRAL SAN FRANCISCO BAY

Survey	Date	Percent Sand	Percent Silt	Percent Clay	Silt:Clay Ratio
ALC					
P	3/73	88.8%	6.5%	4.7%	1:0.72
1	9/73	97.6	1.1	1.3	1:1.18
2	12/73	14.9	81.4	3.7	1:0.04
3	3/74	13.2	37.0	49.8	1:1.34
4	6/74	95.0	0.4	0.1	1:0.25
OIH					
P	3/73	72.3	23.4	4.3	1:0.18
1	9/73	55.1	19.7	25.2	1:1.28
2	12/73	69.9	28.7	1.4	1:0.05
3	3/74	64.1	15.4	20.5	1:1.33
4	6/74	66.2	14.7	19.1	1:1.30
HP					
P	3/73	8.5	71.4	20.1	1:0.28
1	9/73	28.3	28.4	43.3	1:1.52
2	12/73	30.9	64.7	4.4	1:0.07
3	3/74	23.4	32.7	43.9	1:1.34
4	6/74	19.7	28.9	51.4	1:1.78



*Plotted values are means derived from three samples, and represent percent of sample less than the measured grain size.

FIGURE 9 SEDIMENT GRAIN-SIZE DISTRIBUTION FOR STATION ALC*



*Plotted values are means derived from three samples, and represent percent of sample less than the measured grain size.

FIGURE 10 SEDIMENT GRAIN-SIZE DISTRIBUTION FOR STATION OIH*

Results and Discussion

Physical and Chemical Characteristics

Sediment Grain Size

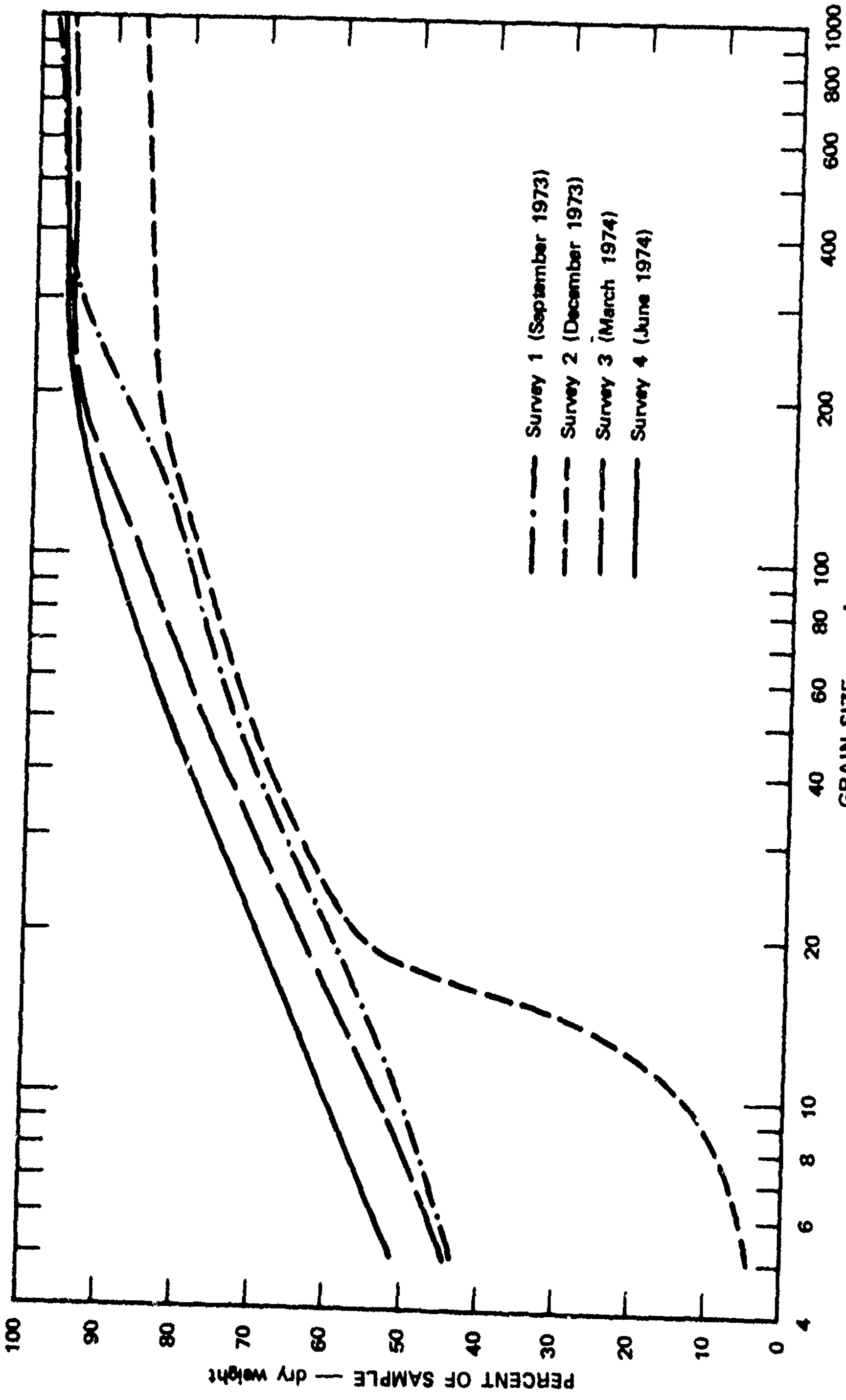
We encountered less sand at HP than at OIH. The average sand content of the sediment at HP was 22.2%. Sediment silt and sand content and ratios varied considerably during the study.

In March and December 1973, the sediment at HP was very silty, the respective percentages being 71.4% and 64.7%. In September 1973 and March and June 1974, the amount of silt in the sediment varied very little, ranging from 28.4% to 32.7%. During these three months, a larger percentage of clay than silt was in the sediment. In December 1973, the ratio of silt to clay was only 1:0.04, as shown in Figure 11. This high proportion of silt to clay was observed at all 11 stations in December 1973 and at some stations in March 1973.

Figure 12 shows that, at the South Bay disposal site, the grain-size distribution of sediment collected from SB-A changed from month to month. In March 1973 (distribution not shown), the silt-to-clay ratio was 1:1.20, and these particles made up 96.3% of the total dry weight of the sample. Table 45 presents the percentages of sand, silt, and clay for the South Bay region. In September, the proportion of sand increased, and the silt-to-clay ratio shifted markedly. The proportion of clay was a little more than twice that of silt; and, together, the silt and clay fraction constituted 91.7% of the sample weight. The proportion of sand, silt, and clay in the March 1974 sediment samples was closer to that calculated in September 1973 than in March 1973.

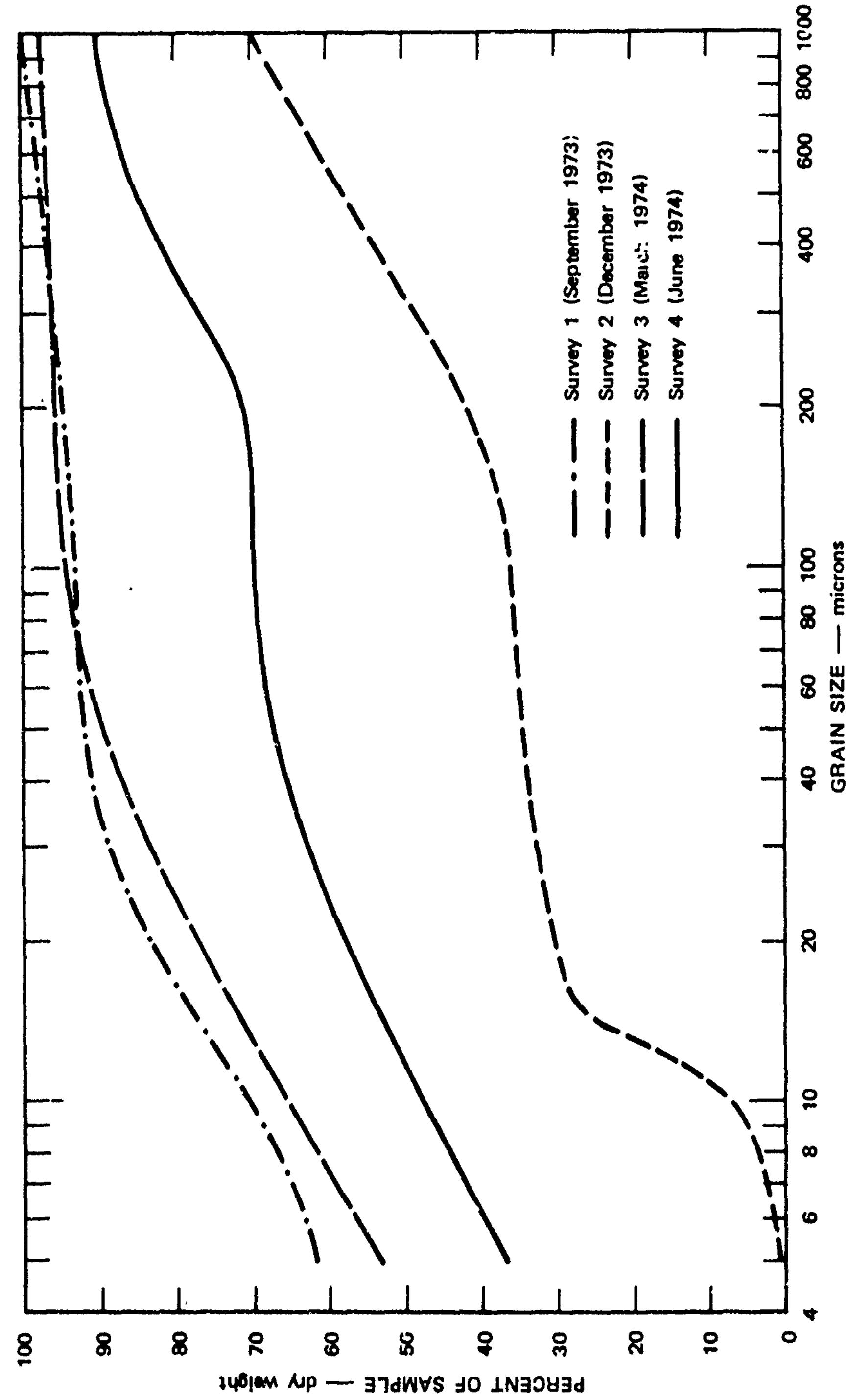
As at all the other stations, we observed a very marked change in the silt-to-clay relationship in December 1973. The sediment usually contained more clay than silt, but, in December, the sediment contained less than 1% clay and about 33% silt. During this month, we also observed a considerable increase in the sand fraction, which comprised nearly a third of the sample. In June, the sediment was composed of nearly equal parts sand, silt, and clay.

The sediment from SB-B did not vary greatly in sand content from month to month and contained an average of 2.4% to 10.0% sand (Table 45). The largest changes occurred in the relative proportions of silt and clay, as shown in Figure 13. The sediment was very silty in March 1973, December 1973, and June 1974. In September 1973 and March 1974, the sediment was more clay-like.



*Plotted values are means derived from three samples, and represent percent of sample less than the measured grain size.

FIGURE 11 SEDIMENT GRAIN-SIZE DISTRIBUTION FOR STATION HP*



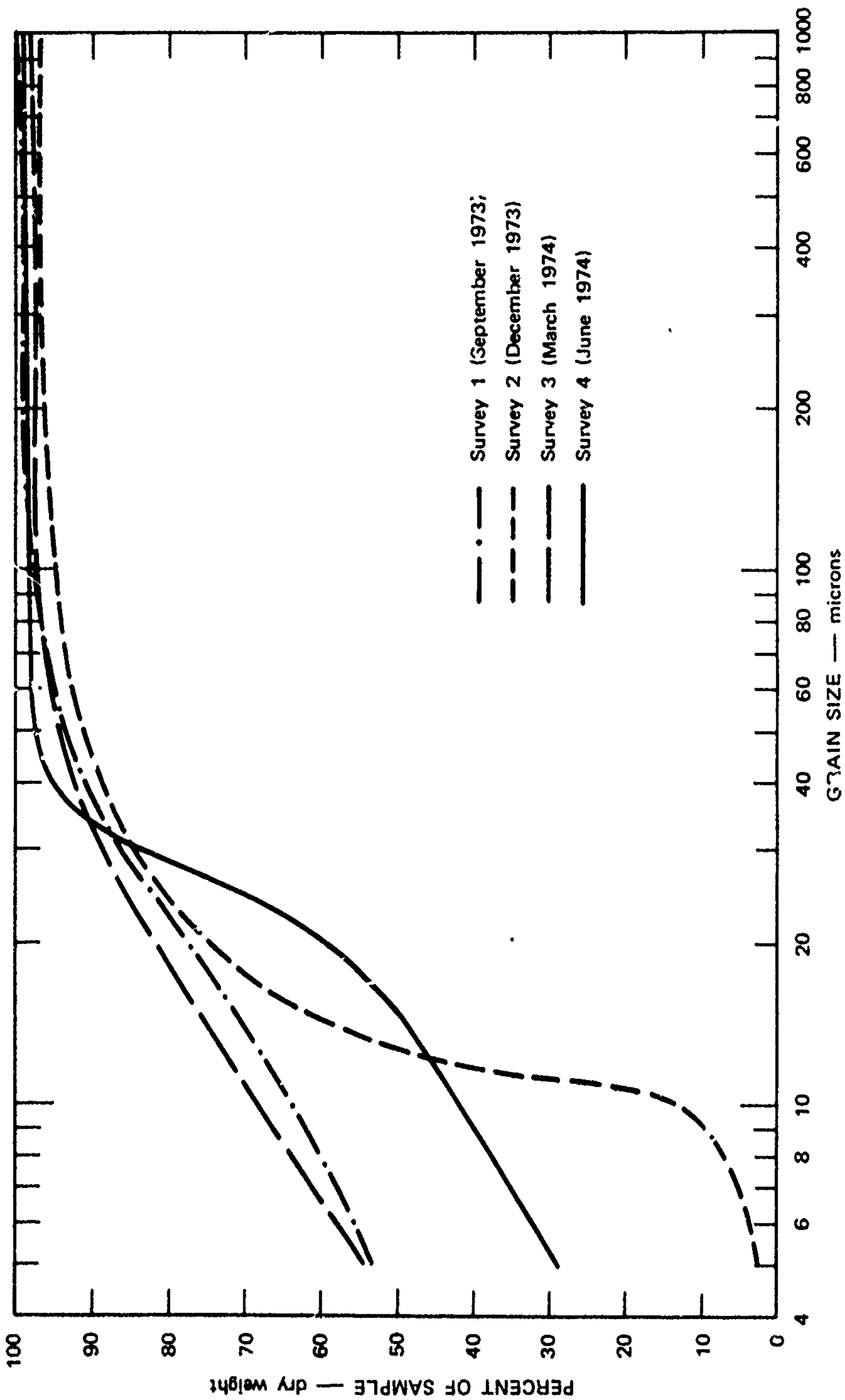
*Plotted values are means derived from three samples, and represent percent of sample less than the measured grain size.

FIGURE 12 SEDIMENT GRAIN-SIZE DISTRIBUTION FOR STATION SB-A*

Table 45

PROPORTION OF SAND, SILT, AND CLAY IN SEDIMENT
OF SOUTH SAN FRANCISCO BAY

Survey	Date	Percent Sand	Percent Silt	Percent Clay	Silt:Clay Ratio
SB-A					
P	3/73	3.7%	43.8%	52.5%	1:1.20
1	9/73	8.3	29.6	62.1	1:2.10
2	12/73	66.1	33.1	0.8	1:0.02
3	3/74	8.3	37.9	53.8	1:1.42
4	6/74	32.9	30.3	36.8	1:1.21
SB-B					
P	3/73	2.4	93.7	3.9	1:0.04
1	9/73	4.8	41.4	53.8	1:1.30
2	12/73	10.0	87.2	2.8	1:0.03
3	3/74	5.7	39.6	54.7	1:1.38
4	6/74	2.9	75.2	29.1	1:0.39
RCH-A					
P	3/73	6.6	40.6	52.8	1:1.30
1	9/73	11.1	30.8	58.1	1:1.89
2	12/73	8.0	78.3	3.7	1:0.05
3	3/74	9.3	34.8	55.9	1:1.61
4	6/74	30.0	26.3	43.7	1:1.66
RCH-B					
P	3/73	5.2	50.4	44.4	1:0.88
1	9/73	6.0	36.7	57.3	1:1.56
2	12/73	3.0	91.2	5.8	1:0.06
3	3/74	3.7	36.0	60.3	1:1.66
4	6/74	2.8	37.5	59.7	1:1.59



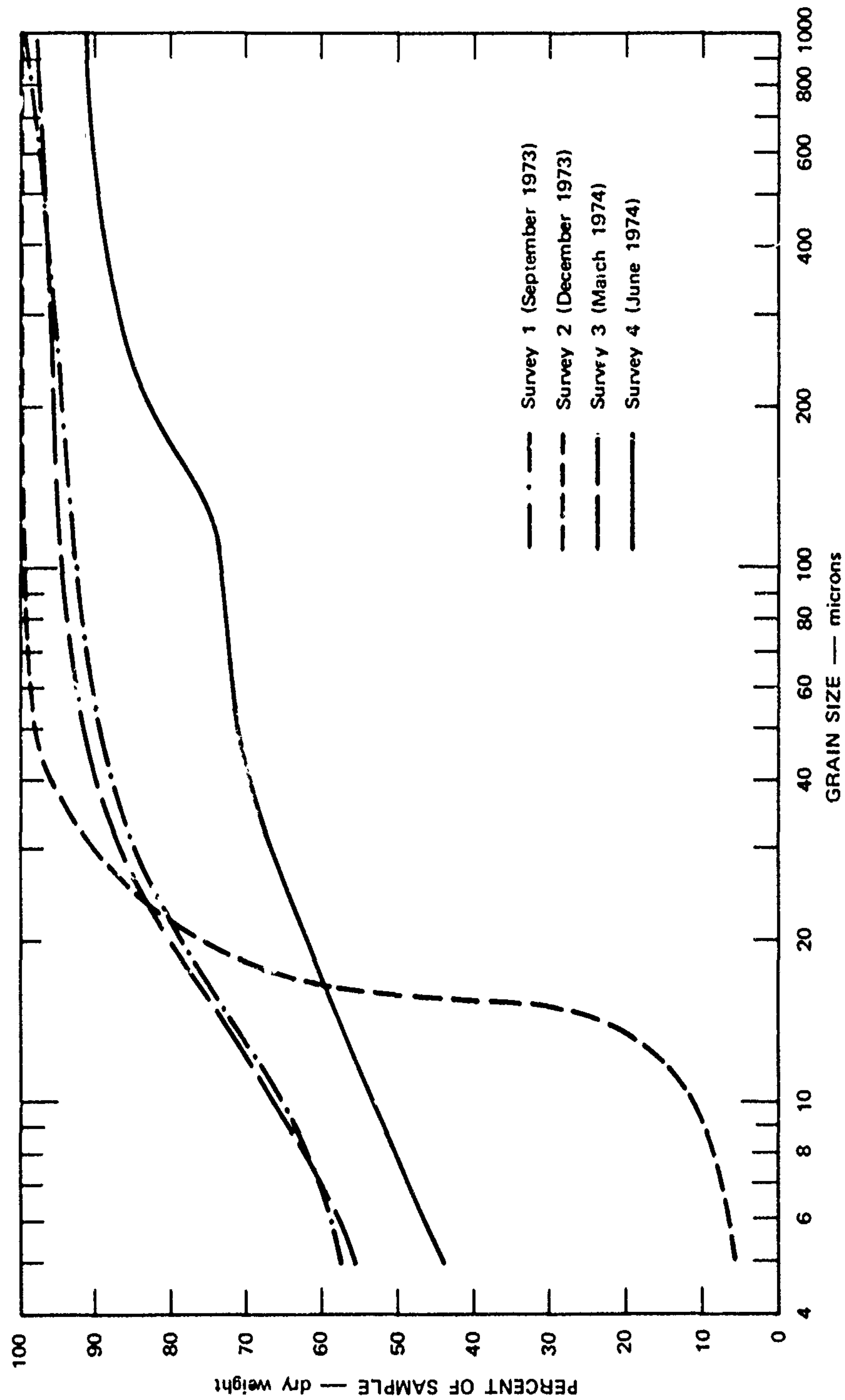
*Plotted values are means derived from three samples, and represent percent of sample less than the measured grain size.

FIGURE 13 SEDIMENT GRAIN-SIZE DISTRIBUTION FOR STATION SB-B*

In general, we found only a small amount of sand in the sediment from the entrance channel to Redwood City Harbor. The sediment from RCH-A contained from about 30% to 89% more clay than silt, except in December when the usual reversal occurred. The samples collected in December contained 78.3% silt and only 3.7% clay (Table 45). The sediment particle-size profiles for September 1973 and March 1974 were quite similar, as shown in Figure 14. If enough data had been obtained for March 1973, that profile probably also would have been similar. In general, the sediment collected in June contained somewhat equal proportions of sand, silt, and clay.

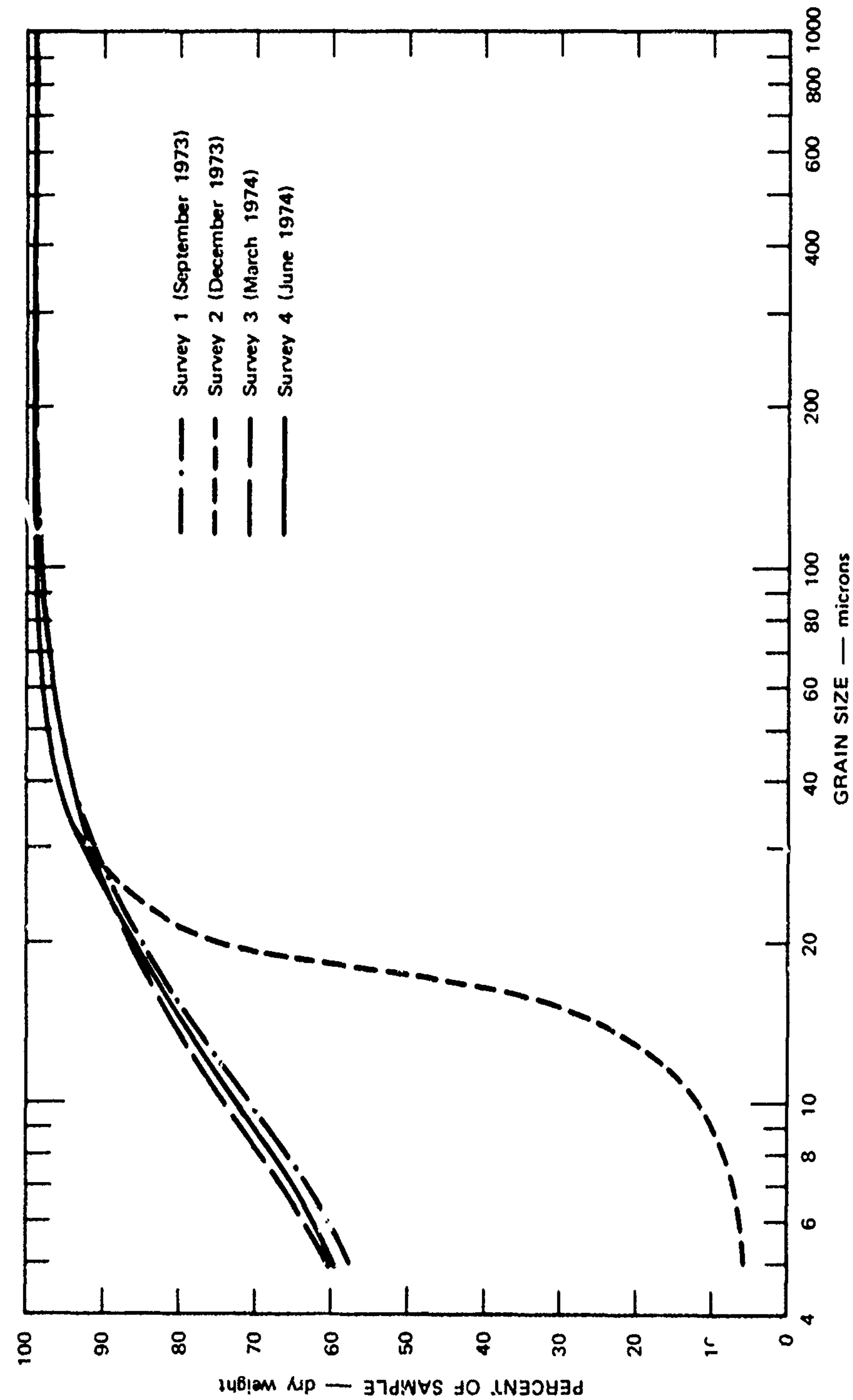
As at RCH-A, the sediment at RCH-B contained a small percentage of sand. The average of the mean sand percentages was 4.1%. Comparatively small changes occurred in the sand content from month to month (Table 45). Figure 15 indicates that the sediment was similar in particle-size composition in September 1973, March 1974, and June 1974.

During September 1973 and March and June 1974, the silt-to-clay ratio ranged from 1:1.56 to 1:1.66. In December, the usual reversal in the proportion of silt and clay occurred. A reversal of lesser magnitude occurred in March 1973.



*Plotted values are means derived from three samples, and represent percent of sample less than the measured grain size.

FIGURE 14 SEDIMENT GRAIN-SIZE DISTRIBUTION FOR STATION RCH-A*



*Plotted values are means derived from three samples, and represent percent of sample less than the measured grain size.

FIGURE 15 SEDIMENT GRAIN-SIZE DISTRIBUTION FOR STATION RCH-B*

ABIOTIC-BIOTIC RELATIONSHIPS

General

Many physical, chemical, and biological factors govern the distribution and abundance of organisms in nature. Because interactions among these factors are often highly complex, identification of the controlling factors can be difficult.

We attempted to identify those physical and chemical parameters measured during this investigation that appeared to influence the kinds and numbers of benthic animals found at each station. We first examined the data without using statistical methods to determine whether any obvious relationships existed. Second, we applied the least-squares method to find out whether more subtle relationships were present. We did not correlate fluctuations in the abundance of individual species with physical or chemical changes in the environment; instead, we sought relationships using the major taxonomic groups (polychaetes, arthropods, and molluscs) as well as the general population data.

Nonstatistical Analyses

Casual inspection of the data revealed few obvious relationships. From the onset, we realized that dissolved oxygen probably would not be a limiting factor, because the observed levels were always at or near saturation and were adequate for all aquatic organisms that we are familiar with. Neither did pH by itself appear limiting, although it could have an effect on sediment chemistry such as the ionic state of sulfides and heavy metals. At none of the stations did changes in sediment grain-size distribution, temperature, turbidity, sulfide levels, or concentrations of any of the heavy metals (one exception) appear to influence the size of the animal populations or the number of taxa present.

Abiotic-Biotic Relationships
Nonstatistical Analysis

Table 46 shows that, where fluvial influences were great (as at Mare Island Strait and the Carquinez Strait disposal site), the sediment was inhabited primarily by oligochaetes and by fewer taxa than where the Bay environment was less influenced by fresh water. At Mare Island Strait and the Carquinez disposal site, the salinity was usually lower and the turbidity of the water was usually higher than at any other area investigated. Both salinity and turbidity, as well as sediment sulfide levels, fluctuated more than at other areas.

We also found the largest assemblages of different kinds of animals at locations where salinity was usually high and water and sediment temperature were usually low. These conditions were observed at OIH, ALC, and HP.

Of all areas investigated, OIH had the largest population of benthic animals during all sampling months except June 1974. The majority of the organisms were oligochaete and polychaete worms. The conditions that enabled the sediment to support the large numbers of organisms were not obvious. However, the sediment sulfide levels at OIH usually were higher and much less variable than those at all the other areas investigated, and during at least one sampling month, the sediment contained more lead, zinc, cadmium, and mercury than did the sediment from other areas. We are not certain of the cause of the marked reduction in the number of taxa and specimens collected in June 1974, but, we did observe that the sediment collected during that month contained about 90% more zinc than did the sediment collected in March 1974. Whatever the cause of the decline, the result was a reduction in the size of the population of all major animal groups.

Another observation was that the undredged portion of Mare Island Strait, MIS-B, supported a larger animal population than the dredged portion, MIS-A. However, MIS-A usually was inhabited by a larger number of taxa. The physical and chemical properties of the water and sediment from MIS-A were not much different from those of MIS-B. The population data presented in Table 46 show that the populations in both areas reached their greatest size in September and that, whereas the size of the population at MIS-B remained relatively large in succeeding months, the size of the population at MIS-A declined markedly in December 1973 and March 1974.

Table 46

NUMBER OF BENTHIC SPECIMENS AND TAXA COLLECTED AT VARIOUS DREDGE AND DISPOSAL AREAS IN SAN FRANCISCO BAY DURING 1973 AND 1974
(Number of Taxa Shown in Parentheses)

	Survey					
Station	P (March 1973)	1 (Sept. 1973)	2 (Dec. 1973)	3 (March 1974)	4 (June 1974)	Total*
MIS-A	132 (11)	8,066 (17)	628 (19)	53 (7)	333 (10)	9,212 (33)
MIS-B	352 (12)	15,773 (12)	15,596 (16)	12,150 (12)	12,307 (10)	56,178 (26)
CS-A	192 (16)	841 (24)	1,419 (20)	300 (18)	5,698 (19)	8,450 (47)
CS-B	34 (15)	4,743 (19)	346 (20)	1,795 (19)	814 (18)	7,732 (48)
ALC	9 (7)	12,764 (58)	888 (82)	7 (9)	1,419 (28)	15,087 (133)
OIH	21,153 (76)	28,784 (66)	41,772 (69)	34,311 (64)	5,236 (44)	131,256 (137)
HP	3,111 (51)	10,514 (50)	1,945 (62)	841 (46)	2,601 (80)	19,012 (138)
SB-A	1,486 (39)	9,680 (48)	8,859 (55)	7,900 (52)	4,721 (52)	32,646 (91)
SB-B	2,765 (43)	6,348 (35)	10,969 (60)	2,456 (43)	10,124 (47)	32,662 (99)
RCH-A	1,425 (42)	19,671 (43)	10,614 (36)	6,921 (44)	21,914 (53)	60,545 (91)
RCH-B	1,965 (48)	2,337 (25)	7,236 (32)	8,526 (31)	14,582 (44)	34,646 (81)

*Taxa totals refer to total number of different taxa.

Although this decline corresponded with a marked lowering of salinity, it also corresponded with times of heavy dredging activity, which occurred in November 1973 and in February through April 1974. We believe the dredged area supports a smaller benthic animal population because the sediment is disturbed to a greater degree by dredging activity at certain times of the year and possibly by a combination of river water flow and tidal action. That salinity changes have little influence is supported by the observation that, although the salinity of the water from MIS-B was lower in December 1973 and March 1974 than at MIS-A, and the change from September to December was greater, the size of the animal population remained relatively stable at MIS-B.

Least-Square Analyses

To analyze the data more completely, we applied the method of least squares. We selected eight dependent variables--the total number of noncolonial specimens per liter, the total number of taxa per liter, the total number of species and specimens of polychaetes per liter, the total number of species and specimens of arthropods per liter, and the total number of species and specimens of molluscs per liter.

The design of the benthic community study is displayed in Table 47, which shows biological and environmental data collected during each of the five surveys.

The pattern of data collection imposes two limitations on the statistical analyses that may be performed. The first limitation is that only one total species and specimen count exists for each combination of station and survey, so the effective number of observations for a combination of variables is the total number of stations times the number of surveys during which that combination of variables was collected. Thus, the number of observations--73--associated with a combination of data, is not large enough for detection of subtle effects on species and specimen counts. The second limitation is that the design of the benthic community study did not allow for the simultaneous estimation of survey effects associated with the time of year and station effects associated with the area surveyed.

Table 47

DESIGN OF BENTHIC COMMUNITY STUDY

Data Collected	Number of Stations	Number of Determinations Survey P (March 1973)	1 (Sept. 1973)	2 (Dec. 1973)	3 (March 1974)	4 (June 1974)
Number of specimens	11	11	11	11	11	11
Number of species	11	11	11	11	11	11
Water temperature	11	22	22	22	22	22
Sediment temperature	11	73	66	66	44	44
Water salinity	11	22	22	22	22	22
Sediment salinity	11	0	0	0	44	44
Water pH	11	22	22	22	22	22
Sediment pH	11	73	66	66	44	44
Total sulfides in water	11	22	22	22	22	22
Total sulfides in sediment	11	73	66	66	33	32
Water turbidity	11	22	22	22	22	22
Sample volume of sediment	11	73	66	66	44	44
Dissolved oxygen in water	11	22	22	22	22	22
Copper in sediment	11	42	33	33	33	33
Cadmium in sediment	11	42	33	33	33	33
Lead in sediment	11	42	33	33	33	33
Zinc in sediment	9	0	0	27	27	27
Mercury in sediment	9	0	0	27	24	27

Although we cannot compensate for the first limitation, we can address the second by analyzing the data by two approaches--one that accounts for station effects but not survey effects and one that accounts for survey effects but not station effects.

The method of collection also imposes a limitation. These data represent an observational study, instead of a random sampling from a well-defined population, implying that the probability statement obtained by application of commonly used statistical techniques must be interpreted cautiously and that analyses of these data should be considered as a description of the data using least-squares theory rather than as an attempt to create a statistical model.

Briefly, the least-squares theory solves for parameters b_1, $b_2, \ldots, b_m$ in a model of the data y, $x_1, x_2, \ldots, x_p$ by minimizing

$$\sum_j^n \left[y_j - f\left(x_{1j}, x_{2j}, \ldots, x_{pj}; b_1, b_2, \ldots, b_m \right) \right]^2 \tag{1}$$

where y is the dependent variable, $x_1 \ldots x_p$ are independent variables, and summation takes place over all the n observations. The interrelations among the data elements are summarized by the parameter estimates $\hat{b}_1, \hat{b}_2, \ldots, \hat{b}_m$, and the fit of the model is summarized by the value of

$$\sum_j^n \left[y_j - f\left(x_{1j}, x_{2j}, \ldots, x_{pj}; \hat{b}_1, \hat{b}_2, \ldots, \hat{b}_m \right) \right]^2 \ . \tag{2}$$

We used a slight extension of this theory for linear f, which allows the possibility that y is a collection of observations instead of a single datum. This theory, developed in Anderson (1958), minimizes the residual sum of squares matrix that corresponds to Equation 1:

$$\sum_j^n \left(Y_j - BX_j \right) \left(Y_j - BX_j \right)' \tag{3}$$

where Y is the vector of eight dependent variables, X is the vector of independent variables, and B is the matrix of parameters.

The primary assumption involved in these analyses is that Equation 3 is the same for each observation of the vector Y. According to least-squares theory, there is no assumption of linearity in that the choice of function is a matter of judgment. A linear function was chosen for these analyses because of its ease of interpretation as well as mathematical convenience. All basic computations were performed by BMD 11V (Dixon, 1973) on a CDC 6400 computer.

Table 47 shows that full analysis of these data requires at least six applications of least-squares methodology. The water data and sediment data must be examined from the point of view of stations and surveys, and the data for zinc and mercury--collected in only three surveys--require separate analyses for stations and for surveys.

Before executing these six analyses, we examined the standard deviations of the independent variables for samples within survey and station to determine how well their mean values would summarize the survey results on these variables. Generally, the raw data indicated that the mean summarized the survey results well, because the standard deviations were generally small. Thus, for all subsequent analyses, the average over samples was used as the independent variable in each of the six regression models.

Because the linear least-squares approach structures the data by assuming a constant deviation from the regression plane, there is a tendency to under-represent the variability of the data. To examine the extent to which this is the case here, we calculated the intercorrelations among the variables for each station by pooling across surveys. These correlations were fairly dissimilar, as were the corresponding correlations for the logarithms of the variables. Based on this result, we decided to use the raw frequency counts as the dependent variable, since they are easiest to interpret. In addition, we concluded that the resultant equations smooth the data considerably.

Abiotic-Biotic Relationships
Least-Square Analyses

Table 48 shows the independent variables for each of the six linear regression equations, the parameters of which were estimated for each of the eight dependent variables. It also shows the surveys on which parameters were estimated. In Equations 1 through 4, sediment data is used, whereas Equations 5 and 6 enable examination of the relationship between the water data and the eight dependent variables. Equations 1 and 3 allow examination of station effects for the sediment data, whereas Equation 5 provides estimates of station effects for the water data. Similarly, Equations 2, 4, and 6 allow estimation of survey effects.

Table 49 shows the coefficients of determination for each of the regression runs for each of the dependent variables. Overall, the table shows the great variation in the adequacy of these equations. The water equation for estimating survey effects is completely unsuccessful in predicting the total number of species. Except for Equations 1 and 3, the number of arthropod species is not predicted very well by any of these data.

Conversely, except for the number of arthropod species and the total number of species, each of the dependent variables has an equation that accounts for at least 60% of the observed variance. Generally, the equations for the number of arthropods and the number of molluscs are particularly good, sometimes accounting for 80% of the observed variance.

Generally, the water data and the sediment data can be predicted equally well. Sometimes one set is superior for a given dependent variable, and sometimes the other is. However, for both sets of data, the total number of species and the total number of polychaetes are predicted best by the equations that take into account station effects, whereas the counts for the other variables are predicted best by the equations that take into account survey effects (except in the equations that examine the effects of mercury and zinc). For total individual counts, the agreement between sediment data and water data does not exist. For the sediment data, the survey equations are superior, and for the water data, the station equation is superior.

Table 48

INDEPENDENT VARIABLES USED IN THE SIX REGRESSION EQUATIONS

	Equation 1: Surveys 2,3,4[a]	Equation 2 Surveys 1,2,3,4[b]	Equation 3 Surveys 2,3,4[c]	Equation 4 Surveys 1,2,3,4[d]	Equation 5: Surveys P,1,2,3,4[e]	Equation 6: Surveys P,1,2,3,4[f]
X_1	Temperature	Sample volume	Temperature	Sample volume	Temperature	Temperature
X_2	Zinc	Temperature	Zinc	Temperature	Salinity	Salinity
X_3	Mercury	Total sulfides	Mercury	Total sulfides	D.O.	D.O.
X_4	North stations	pH	Survey 2	pH	Turbidity	Turbidity
X_5	Alcatraz	Lead	Survey 3	Lead	pH	Total sulfides
X_6	Central stations	Cadmium	Constant	Cadmium	Depth	pH
X_7	Constant	Copper		Copper	MIS-A	Depth
X_8		Silt		Silt	MIS-B	Survey P
X_9		Clay		Clay	CS-A	Survey 1
X_{10}		MIS-A		Survey 1	CS-B	Survey 2
X_{11}		MIS-B		Survey 2	ALC	Survey 3
X_{12}		CS-A		Survey 3	OIB	Constant
X_{13}		CS-B		Constant	HP	
X_{14}		ALC			SB-A	
X_{15}		OIB			SB-B	
X_{16}		HP			RCH-A	
X_{17}		SB-B			Constant	
X_{18}		Constant				

[a] $-\sum_{i=4}^{6} X_i$ = South stations.

[b] $-\sum_{i=10}^{17} X_i$ = RCH-B.

[c] $-\sum_{i=4}^{5} X_i$ = Survey 1.

[d] $-\sum_{i=10}^{13} X_i$ = Survey 1.

[e] $-\sum_{i=7}^{16} X_i$ = RCH-B.

[f] $-\sum_{i=8}^{12} X_i$ = Survey 1.

Table 49

COEFFICIENTS OF DETERMINATION

	Dependent Variables	Independent Variables					
		Sediment-Station Effects (Eq. 1)	Sediment-Station Effects (Eq. 2)	Sediment-Survey Effects (Eq. 3)	Sediment-Survey Effects (Eq. 4)	Water-Station Effects (Eq. 5)	Water-Survey Effects (Eq. 6)
1	Total specimens	0.230495	0.493634	0.692746	0.681674	0.809990	0.651279
2	Total species	0.508097	0.675920	0.212475	0.412727	0.383505	0.041197
3	Total polychaetes	0.515535	0.78245	0.429015	0.453688	0.392815	0.182632
4	Total Polychaete spp.	0.808455	0.531338	0.497265	0.694679	0.504883	0.844813
5	Total molluscs	0.919301	0.348910	0.816610	0.892651	0.690219	0.921750
6	Total Mollusc spp.	0.631786	0.520644	0.879124	0.695512	0.743057	0.773438
7	Total arthropods	0.953289	0.544989	0.900416	0.809805	0.732951	0.774313
8	Total Arthropod spp.	0.452586	0.014424	0.411557	0.050125	0.013396	0.030371

This reversal, together with the large variation in the effectiveness of the equations, reveals the complexity of the relations that underlie these data. Table 50 shows the correlation among the dependent variables after removing the variation predicted by the models. The numbers on the main diagonals are the standard errors of the dependent variables. This table confirms that the interrelations are variable and that the picture of the interrelations strongly depends on which equation is being examined.

Comparison of the standard errors for the dependent variables in each of these models shows that, although variation occurs from equation to equation, Equations 1 and 3 are particularly unsuccessful, but Equation 5 is generally good. Equations 1 and 2 are also different from the other sediment equations in that they indicate a preponderance of negative correlations (the others show a preponderance of positive correlations). However, since Equations 1 and 3 are based on fewer observations than the others, the disagreements may not be important.

It is interesting that, for the equation using water variables, the residual correlations are generally negative when stations are considered in the equation; however, the correlations are generally positive when the surveys are considered. The implication is that large errors in long-range predictions may occur because of failure to account for this interaction between station and survey.

Table 51 shows the values of estimated parameters for each of the six models. Tables 52 through 57 show the results of hypothesis tests on the estimated parameters. All hypothesis tests shown are multivariate in the sense that they test whether effects are zero for all dependent variables simultaneously. The F statistics are exact if the dependent variables are multivariate normal and if either A or C, shown in the tables, is either 1 or 2. "C" indicates the number of dependent variables being considered, and "A" refers to the number of covariables or independent variables being considered in the hypothesis tests. Otherwise, the F tests are approximate (see Dixon, 1973). In the following discussion, unless otherwise qualified, "significant" means $p \leqq 0.05$ under the assumption that the F test is valid.

Table 50

RESIDUAL CORRELATIONS AMONG THE EIGHT DEPENDENT VARIABLES

Equation 1

	1	2	3	4	5	6	7	8
1	0.076105	-0.466255	-0.416919	-0.008161	-0.072069	0.105982	-0.072248	-0.439308
2		6.560012	0.861569	-0.325127	0.403862	-0.082062	0.324906	0.939118
3			70.737868	-0.208346	0.389872	-0.214847	0.204963	0.861288
4				1.639041	-0.101459	0.061803	0.088881	-0.388558
5					0.446598	0.547134	0.318121	0.423570
6						0.305800	0.402918	-0.075748
7							0.459860	0.323945
8								0.464909

Equation 2

	1	2	3	4	5	6	7	8
1	0.284999	0.269189	0.558504	0.550638	0.718791	0.710473	0.488951	0.004109
2		0.390243	-0.168151	0.160475	0.412646	0.187745	0.295093	0.302605
3			0.391584	0.528941	0.398366	0.376016	0.554118	0.093266
4				0.306769	0.721597	0.384455	0.497155	0.170189
5					0.201443	0.432892	0.538691	-0.176027
6						0.300594	0.087291	0.260483
7							0.314650	-0.070283
8								0.020399

Table 50 (Continued)

Equation 3

	1	2	3	4	5	6	7	8
1	49.146566	0.302971	-0.015037	-0.323333	0.159937	-0.343662	-0.231773	-0.234003
2		0.077935	-0.448840	-0.473936	0.040781	0.199967	0.070159	-0.477931
3			6.402645	0.82006	-0.32331	-0.510915	-0.133409	0.916461
4				72.951738	-0.246330	-0.243759	0.083411	0.868058
5					1.620401	0.029183	-0.316964	-0.410333
6						0.813911	0.427409	-0.192567
7							0.833623	0.189211
8								0.466661

Equation 4

	1	2	3	4	5	6	7	8
1	0.23011	0.41705	-0.237143	0.299675	0.359524	0.135898	0.555255	0.45693
2		8.265371	0.359241	-0.037926	0.19962	0.355155	0.111668	0.431443
3			18.666432	-0.537899	0.02049	0.532463	-0.415726	0.109237
4				21.140766	-0.00502	-0.452108	0.465317	0.132574
5					0.789105	0.790305	0.801905	0.438155
6						0.614229	0.32153	0.51201
7							0.716341	0.325349
8								0.022185

Table 5C (Concluded)

Equation 5

	1	2	3	4	5	6	7	8
1	0.364678	0.232582	0.343813	0.167655	0.123894	0.204749	0.324764	-0.131365
2		0.172664	0.29265	-0.522212	-0.008931	0.252320	0.122779	-0.091046
3			0.176855	-0.115957	-0.143194	0.043095	0.29939	-0.099742
4				0.227311	-0.214849	-0.068181	-0.064603	0.1215
5					0.310754	0.039451	0.043672	-0.215505
6						0.334543	0.04735	-0.083495
7							0.329993	-0.35739
8								0.016333

Equation 6

	1	2	3	4	5	6	7	8
1	2.182329	0.214234	0.19064	0.684496	0.339042	0.439404	0.014407	0.457129
2		0.355936	0.457377	0.153972	-0.375659	-0.296989	-0.095644	0.834752
3			8.471614	0.197512	-0.029094	-0.002005	-0.040365	0.498713
4				0.604277	0.641292	0.489577	0.406353	0.392871
5					0.659304	0.767862	0.724857	-0.025246
6						0.553225	0.268423	0.163739
7							0.540923	-0.101919
8								0.033932

Table 51

REGRESSION COEFFICIENTS

Independent Variables*	Dependent Variables† 1	2	3	4	5	6	7	8
Equation 1								
1	-0.00010	0.04387	0.25533	-0.00087	-0.00024	0.00236	0.00019	0.00164
2	0.50856	13.26398	1.43151	3.67816	0.86886	0.34602	0.26572	0.74711
3	-0.00018	-0.02020	-0.17731	-0.00142	-0.00094	-0.00300	-0.00155	-0.00092
4	-0.44382	-22.44807	-4.65696	-9.94927	-1.45404	-0.24327	-0.18756	-1.46942
5	0.00129	-0.16008	-2.00109	0.03218	0.01042	-0.00962	-0.00674	-0.01224
6	-0.60593	18.72075	453.62615	1.09172	-1.35066	-1.54494	-0.76030	2.70883
7	0.00048	-0.00196	-0.47995	-0.00527	-0.00264	-0.00619	-0.00366	-0.00222
Equation 2								
1	0.00275	-0.00010	-0.00011	-0.00060	0.00097	0.00008	0.00070	-0.00004
2	1.39236	1.39246	0.06741	1.20583	0.23642	1.63658	1.17598	-0.03762
3	-0.00373	-0.00114	-0.00142	-0.00169	-0.00157	-0.00199	-0.00114	-0.00008
4	-1.33120	-0.90073	0.32723	0.90290	0.06289	-0.50136	-0.62394	0.05405
5	-0.01160	0.00261	0.00580	-0.00219	0.00136	0.00151	-0.00728	-0.00014
6	-2.73588	-3.21646	1.50285	-2.85298	-0.58268	-3.12536	-2.46522	-0.11730
7	-0.00266	0.00120	0.00026	-0.00101	-0.00065	0.00120	-0.00006	0.00006
8	-0.61125	-1.45721	-0.95416	-0.73608	0.11639	-2.06984	-0.43263	-0.03247
9	0.09768	0.07236	0.05548	0.02610	0.04754	0.07636	0.17516	0.00147
10	-0.06920	-0.10106	-0.04155	-0.01105	-0.03675	-0.08490	-0.06957	0.00457
11	0.00021	0.00043	0.00022	-0.00009	0.00057	0.00002	0.00102	-0.00001
12	-0.21870	0.03396	0.01177	-0.00533	-0.09788	-0.12234	-0.43963	0.12551
13	-0.01328	-0.04484	-0.03084	-0.01893	-0.00376	-0.00827	-0.2409	-0.00197
14	-0.00303	0.01091	-0.08146	0.62761	0.08707	-0.52005	-0.04245	0.04053
15	0.00615	0.03201	0.02059	-0.00526	0.00261	0.01771	0.00168	0.00074

Table 51 (Continued)

Independent Variables*	Dependent Variables† 1	2	3	4	5	6	7	8
16	-0.01075	-0.01664	-0.01739	-0.00658	-0.01083	-0.01144	-0.01603	-0.00002
17	-0.00795	-0.01448	-0.01502	-0.00909	-0.00950	-0.00457	-0.00976	-0.00028
18	0.38702	0.13567	0.36768	0.31712	0.61260	0.45427	0.70068	-0.00284
				Equation 3				
1	0.14119	-0.00004	0.02360	0.18757	-0.00013	-0.00177	-0.00124	0.00133
2	-30.56969	0.49388	13.32386	16.10333	3.51696	-1.25746	-1.42571	0.81504
3	0.16653	-0.00010	-0.02053	-0.25723	0.00229	0.00298	-0.00068	-0.00129
4	58.98127	-0.41549	-22.56361	-32.96481	-9.63825	1.21138	1.68130	-1.60048
5	-2.80012	-0.00005	-0.15459	-0.65718	0.01742	0.00860	0.02509	-0.00602
6	108.24135	-0.55393	18.50871	401.67610	1.66250	5.04851	4.37706	2.46832
				Equation 4				
1	-0.00037	0.00546	0.02919	0.00998	-0.00036	-0.00011	-0.00050	-0.00005
2	0.79324	-29.96663	7.14585	-30.16157	0.52358	-0.35005	-0.51460	-0.02208
3	0.00065	-0.00120	-0.01416	-0.00458	0.00096	0.00151	0.00060	0.00011
4	-1.50565	34.75580	-12.03997	41.64118	-0.56426	0.47604	0.70473	0.00958
5	0.00241	0.01644	-0.33567	-0.14767	0.00609	-0.00129	0.00609	-0.00003
6	-1.73654	24.24044	27.64524	-20.52045	0.42974	2.39833	0.74843	0.07820
7	-0.00063	-0.11108	-0.04246	0.00937	-0.00148	-0.00202	0.00021	-0.00005
8	0.43839	46.10967	42.95131	28.99278	-0.73941	0.54097	-0.29637	0.01303
9	0.04241	2.03433	5.83688	0.34231	0.10006	0.11876	0.02927	0.00435
10	-0.00348	2.65157	-3.66549	2.55945	0.04968	-0.10343	-0.10398	0.00573
11	-0.00010	-0.02890	0.00700	-0.01289	-0.00043	-0.00034	-0.00019	-0.00003
12	-0.13066	-10.27911	-10.88071	-0.54064	-0.53589	-0.29148	0.11986	0.11333
13	0.02746	0.94211	-0.66817	0.09624	-0.00192	-0.01053	-0.00086	-0.00016

Table 51 (Continued)

Independent Variables*	Dependent Variables† 1	2	3	4	5	6	7	8
				Equation 5				
1	-0.00069	-0.00002	-0.00048	-0.00045	-0.00086	-0.00113	0.00011	0.00002
2	-0.84861	0.28676	-0.57733	--0.32280	0.86484	-0.43005	0.25671	-0.04887
3	0.00062	0.00058	0.00068	-0.00040	-0.00166	0.00162	-0.00042	0.00006
4	1.14858	-0.82941	0.89863	1.64999	-0.66870	0.68800	-0.16404	0.04523
5	0.00681	-0.00073	0.00905	-0.00013	0.01787	-0.00017	0.00059	-0.00032
6	1.70561	-0.63141	1.12328	0.48846	-0.58246	0.87220	-0.73921	0.09288
7	0.00093	-0.00015	-0.00007	0.00087	0.00212	0.00128	0.00225	-0.00002
8	-0.03585	0.45356	0.20562	-0.99201	-1.61619	0.14909	-0.23734	0.06042
9	0.04076	-0.02287	-0.00985	-0.01876	0.00798	-0.00295	-0.02867	0.00645
10	0.00047	0.02456	0.01168	-0.00677	0.01132	0.02623	0.00820	0.00238
11	0.12605	0.06410	-0.07155	-0.16358	0.07147	0.08993	0.00040	0.03503
12	0.00001	0.00000	-0.00001	-0.00002	0.00001	0.00000	-0.00001	0.00000
13	0.00166	-0.01137	-0.00580	-0.01193	0.00983	-0.00112	0.01179	0.00450
14	-0.28671	-0.17210	0.06729	0.16097	-0.13646	-0.08818	0.01339	0.07145
15	0.01784	0.01871	-0.00147	0.00885	-0.00065	-0.01109	0.00006	0.00031
16	0.24836	0.37689	0.37653	0.40919	0.25266	0.36223	0.37779	0.00947
17	0.49202	0.48535	0.43278	0.54167	0.44625	0.48145	0.29040	0.00108
18	-0.01510	-0.05843	0.18561	0.01406	0.17881	0.29623	0.25985	0.00032

Table 51 (Concluded)

Independent Variables*	Dependent Variables†							
	1	2	3	4	5	6	7	8
				Equation 6				
1	-0.00536	-0.00075	-0.02988	-0.00164	-0.00014	0.00024	0.00015	-0.00007
2	-1.87919	-0.04830	36.07179	-0.72118	-0.97524	-1.29867	-1.21410	-0.03824
3	0.01129	0.00056	0.01239	0.00229	0.00162	0.00151	0.00037	0.00015
4	-0.20088	0.15417	-41.32112	0.57110	0.74192	1.12087	1.31324	0.03068
5	0.00569	0.00856	0.10640	0.00957	-0.00321	-0.00726	0.00090	0.00041
6	-2.35081	-0.71299	-62.62781	0.54839	1.80644	2.78630	1.82623	-0.01482
7	0.00386	0.00086	0.00085	0.00144	0.00029	0.00037	0.00058	0.00006
8	7.08730	-0.42270	-31.61539	0.04663	0.46971	1.66646	0.40463	0.04590
9	0.04687	0.09713	-0.17810	-0.03955	0.00851	-0.09444	-0.09936	0.01377
10	-0.07606	0.04495	0.74723	0.00939	0.02470	0.01314	0.02924	0.00519
11	0.48076	0.69815	3.72378	0.10446	-0.04187	0.12384	0.13028	0.08843
12	-0.00008	0.00007	-0.00003	-0.00001	0.00001	0.10001	0.00005	0.00001

*See Table 48.

†See Table 49.

Table 52

HYPOTHESIS TEST RESULTS FOR EQUATION 1

Hypothesis	A	C	df	F*	Significance 0.1	Significance 0.05
All variables = 0	6	8	48, 68	5.121		+
Temperature = 0	1	8	8, 13	9.485		+
Zinc = 0	1	8	8, 13	7.447		+
Mercury = 0	1	8	8, 13	1.499		
All stations = 0	3	8	24, 38	2.777		+
North stations = 0	1	8	8, 13	4.826		+
ALC = 0	1	8	8, 13	1.755		
Central stations = 0	1	8	8, 13	1.694		
South stations = 0	1	8	8, 13	2.528	+	
Difference between the coefficients of the covariables:						
3 and 5 = 0	3	1	3, 20	1.918		
3 and 7 = 0	3	1	3, 20	1.907		
5 and 7 = 0	3	1	3, 20	0.391		
4 and 6 = 0	3	1	3, 20	1.482		
4 and 8 = 0	3	1	3, 20	0.806		
6 and 8 = 0	3	1	3, 20	0.524		

*F statistic.

Table 53

HYPOTHESIS TEST RESULTS FOR EQUATION 2

Hypothesis	A	C	df	F	Significance 0.1	Significance 0.05
All variables = 0	17	8	136, 93	11.756		+
Sample volume = 0	1	8	8, 11	9.538		+
Temperature = 0	1	8	8, 11	2.085		
Total sulfides = 0	1	8	8, 11	1.688		
pH = 0	1	8	8, 11	1.414		
Lead = 0	1	8	8, 11	2.311		
Cadmium = 0	1	8	8, 11	3.507		+
Copper = 0	1	8	8, 11	2.371		
Silt = 0	1	8	8, 11	1.703		
Clay = 0	1	8	8, 11	2.973	+	
All stations = 0	8	8	64, 70	3.787		+
MIS-A = 0	1	8	8, 11	1.546		
MIS-B = 0	1	8	8, 11	1.894		
CS-A = 0	1	8	8, 11	31.100		+
CS-B = 0	1	8	8, 11	1.986		
ALC = 0	1	8	8, 11	1.577		
OIH = 0	1	8	8, 11	1.908		
HP = 0	1	8	8, 11	2.569	+	
SB-B = 0	1	8	8, 11	2.651	+	
RCH-B = 0	1	8	8, 11	8.134		+
Difference between the coefficients of the covariables for dependent variables:						
3 and 5 = 0	9	1	9, 18	2.260		
3 and 7 = 0	9	1	9, 18	1.943		
5 and 7 = 0	9	1	9, 18	4.380		+
4 and 6 = 0	9	1	9, 18	1.579		
4 and 8 = 0	9	1	9, 18	1.559		
6 and 8 = 0	9	1	9, 18	4.143		+

Table 54

HYPOTHESIS TEST RESULTS FOR EQUATION 3

Hypothesis	A	C	df	F	Significance 0.1	Significance 0.05
All variables = 0	6	8	48, 73	4.412		+
Temperature = 0	1	8	8, 14	1.096		
Zinc = 0	1	8	8, 14	9.668		+
Mercury = 0	1	8	8, 14	0.454		
All surveys = 0	2	8	16, 28	2.719		+
Survey 2 = 0	1	8	8, 14	5.316		+
Survey 3 = 0	1	8	8, 14	1.125		
Survey 4 = 0	1	8	8, 14	5.312		+
Difference between the coefficients of the covariables for dependent variables:						
3 and 5 = 0	3	1	3, 21	2.394		
3 and 7 = 0	3	1	3, 21	3.671		
5 and 7 = 0	3	1	3, 21	1.480		
4 and 6 = 0	3	1	3, 21	1.206		
4 and 8 = 0	3	1	3, 21	1.184		
6 and 8 = 0	3	1	3, 21	2.651		

Table 55

HYPOTHESIS TEST RESULTS FOR EQUATION 4

Hypothesis	A	C	df	F	Significance 0.1	Significance 0.05
All variables = 0	12	8	96, 118	9.535		+
Sample volume = 0	1	8	8, 16	0.529		
Temperature = 0	1	8	8, 16	3.566		+
Total sulfides = 0	1	8	8, 16	0.530		
pH = 0	1	8	8, 16	3.998		+
Lead = 0	1	8	8, 16	0.286		
Cadmium = 0	1	8	8, 16	2.414		
Copper = 0	1	8	8, 16	2.072		
Silt = 0	1	8	8, 16	0.893		
Clay = 0	1	8	8, 16	2.717	+	
All surveys = 0	3	8	24, 47	20.666		+
Survey 1 = 0	1	8	8, 16	60.777		+
Survey 2 = 0	1	8	8, 16	1.619		
Survey 3 = 0	1	8	8, 16	43.324		+
Survey 4 = 0	1	8	8, 16	43.514		+
Difference between the coefficients of the covariables for dependent variables:						
3 and 5 = 0	9	1	9, 23	3.418		+
3 and 7 = 0	9	1	9, 23	3.324		+
5 and 7 = 0	9	1	9, 23	1.030		
4 and 6 = 0	9	1	9, 23	0.796		
4 and 8 = 0	9	1	9, 23	0.810		
6 and 8 = 0	9	1	9, 23	1.136		

Table 56

HYPOTHESIS TEST RESULTS FOR EQUATION 5

Hypothesis	A	C	df	F	Significance 0.1	Significance 0.05
All variables = 0	17	8	136, 232	13.932		+
Temperature = 0	1	8	8, 30	1.539		
Salinity = 0	1	8	8, 30	1.614		
D.O. = 0	1	8	8, 30	0.890		
Turbidity = 0	1	8	8, 30	2.503	+	
Total sulfides = 0	1	8	8, 30	3.707		+
pH = 0	1	8	8, 30	1.628		
Depth = 0	1	8	8, 30	2.029		
All stations = 0	10	8	80, 199	12.752		+
MIS-A = 0	1	8	8, 30	1.513		
MIS-B = 0	1	8	8, 30	5.889		+
CS-A = 0	1	8	8, 30	5.349		+
CS-B = 0	1	8	8, 30	6.987		+
ALC = 0	1	8	8, 30	2.406	+	
OIH = 0	1	8	8, 30	2.204		
HP = 0	1	8	8, 30	9.506		+
SB-A = 0	1	8	8, 30	4.996		+
SB-B = 0	1	8	8, 30	14.139		+
RCH-A = 0	1	8	8, 30	16.728		+
RCH-B = 0	1	8	8, 30	4.655		+
Difference between the coefficients of the covariables for dependent variables:						
3 and 5 = 0	7	1	7, 43	4.995		+
3 and 7 = 0	7	1	7, 43	5.100		+
5 and 7 = 0	7	1	7, 43	0.463		
4 and 6 = 0	7	1	7, 43	1.589		
4 and 8 = 0	7	1	7, 43	0.964		
6 and 8 = 0	7	1	7, 43	0.899		

Table 57

HYPOTHESIS TEST RESULTS FOR EQUATION 6

Hypothesis	A	C	df	F	Significance 0.1	Significance 0.05
All variables = 0	11	8	88, 246	16.383		+
Temperature = 0	1	8	8, 36	1.596		
Salinity = 0	1	8	8, 36	3.241		+
D.O. = 0	1	8	8, 36	0.779		
Turbidity = 0	1	8	8, 36	1.933		
Total sulfides = 0	1	8	8, 36	1.003		
pH = 0	1	8	8, 36	2.014		
Depth = 0	1	8	8, 36	0.305		
All surveys = 0	4	8	32, 134	46.924		+
Survey P = 0	1	8	8, 36	3.156		+
Survey 1 = 0	1	8	8, 36	83.276		+
Survey 2 = 0	1	8	8, 36	8.782		+
Survey 3 = 0	1	8	8, 36	286.983		+
Survey 4 = 0	1	8	8, 36	4.219		+
Difference between the coefficients of the covariables for dependent variables:						
3 and 5 = 0	7	1	7, 37	3.059	+	
3 and 7 = 0	7	1	7, 37	6.920		+
5 and 7 = 0	7	1	7, 37	1.882		
4 and 6 = 0	7	1	7, 37	1.134		
4 and 8 = 0	7	1	7, 37	5.950		+
6 and 8 = 0	7	1	7, 37	1.085		

As shown in Table 48, Equations 1 and 3 were designed to assess the effects of zinc and mercury and were based on the results of Surveys 2 through 4 (December 1973, March 1974, and June 1974). The first equation examines station effects by grouping the stations into three categories:

(1) North stations: MIS-A, MIS-B, CS-A, CS-B

(2) ALC

(3) OIH, HP.

The estimated effects of the southern stations, RCH-B and SB-B, are represented as the negative of the sum of the other station effects. Similarly, Equation 3 examines the effect of zinc and mercury in the presence of survey effects. The effect of temperature was included to help control for station effects in the survey equation and survey effects in the station equation.

Comparison of the regression coefficients in Table 51 shows that the station equations and the survey equations do not agree very well on the effects of zinc and mercury. Still, zinc apparently was associated with increases in the dependent variables in general, and mercury was associated with decreases. In both equations, increased temperature was associated with increase in the dependent variables. Hypothesis tests (Tables 52 and 57) to determine whether these effects might be zero show that, in both equations, the zinc effect was significant but the mercury effect was not. The effect of temperature was significant in the equation for stations but not in the one for surveys, indicating that temperature effects were associated more closely with the survey effects than with the station effects.

Equation 1 shows that large differences exist among stations, even considering the differences in temperature and concentration of metals. The hypothesis tests indicate that both survey and station effects are significant. Southern stations are the sites of more life than northern ones. For most dependent variables, even considering other data, there is a slight increasing trend from Survey 2 (September 1973) through Survey 4 (June 1974), although the total individual count was decreasing. Neither

equation indicates that the effects for temperature, mercury, and zinc were significantly different for the various group and specimen counts.

Table 51 shows the estimated parameters for Equations 2 and 4. Using these equations, we examined the heavy-metal data, excluding these for zinc and mercury, for Surveys 1 through 4 from all stations except RCH-A and SB-A. For these stations, the effects of sediment grain size, pH, and total sulfides also were examined.

In Equation 2, temperature has a generally positive effect on the dependent variables; whereas, in Equation 4, the effect is mixed, tending to be negative. The impact of total sulfides also is reversed between the two equations; the effect is negative when stations are included in the equation, and it is positive when surveys are considered. However, as can be seen in Table 51, the hypothesis that these effects are zero fails to reject, except in the case of temperature. By this criterion, neither lead, copper, nor the percentage of the sediment between 5 and 43 μ (silt) has any effect. In both equations, the percentage of sediment less than 5 μ (clay) does have an effect at $p < 0.1$, and the coefficients are positive for both equations. Cadmium shows a significant, generally negative, effect in the station equation, and pH shows a significant, generally positive, effect in the survey equations.

We rejected the hypotheses that no station effects existed and that no survey effects existed. In general--even after taking into account the heavy-metal, sediment, and other data--we found that the northern stations were associated with smaller values of the dependent variables than were the southern stations. MIS-A and MIS-B were estimated to have fairly dissimilar effects, MIS-A generally having less life than MIS-B. For CS-A and CS-B, CS-A had a smaller value for the dependent variables. Hypothesis tests that the station effects were zero indicated that CS-A, with a generally negative effect, and RCH-B with a generally positive one, were not zero with $p < 0.05$. The hypothesis that the HP and SB-B effects, also negative, were zero was rejected at $p < 0.1$.

The estimated survey effects showed an irregular pattern. Hypothesis tests that survey effects were zero were rejected for

all surveys except Survey 2. When this effect is dropped, the survey effects generally follow a U-shaped pattern from Survey 1 to Survey 4.

Both equations indicate that significant differences existed in the way the heavy metals, total sulfides, and sediment grain size affected the dependent variables. Equation 2 indicates such a difference for polychaetes and molluscs as well as for polychaetes and arthropods. The arthropods appeared to be somewhat more sensitive to these variables than the molluscs, and the polychaetes seemed more sensitive than the arthropods. However, the relationships are diverse and difficult to summarize, especially in view of the generally poor fit of the equations to the data.

Equations 5 and 6 are designed to examine station and survey effects, respectively, for the water variables temperature, salinity, dissolved oxygen, turbidity, total sulfides, pH, and depth at which samples were taken. As can be seen in Table 51, salinity had a generally negative effect on the dependent variables in both equations, but dissolved oxygen and turbidity had generally positive effects. In the station equation, total sulfides had a mixed effect on the dependent variables; but, in the survey equation, the effect was generally positive. Depth and pH have mixed effects in both equations.

The hypothesis tests shown in Tables 56 and 57 indicate that only turbidity and total sulfides were significantly different from zero in Equation 5. However, in Equation 6, salinity was the only significant difference among the water variables.

These equations indicate that, given the differences in the other variables, both station and survey effects were significant. The station effects were generally consistent with those noted for the sediment data: MIS-A had less effect than MIS-B; CS-A had less than CS-B; SB-A had less than SB-B. However, the tendency for the effect of the north stations to have had less life was not as pronounced in these equations. The effect of adding the data from the preliminary survey was to change the pattern of estimated survey effects so that they were more generally linear, decreasing from the preliminary survey to Survey 4.

Both equations indicate that the water variables had different effects on the dependent variables, the primary differences being that effects for polychaetes differ from those for molluscs and arthropods.

Our examination of the effects of data collected on sediment and on water for the number of individuals and the number of species found in the San Francisco Bay support the following conclusions:

- The underlying relations among organisms and the other variables are complex.
- The picture of these relationships changes depending on whether station effects or survey effects are considered. The dependent variables tend to be negatively correlated when stations are considered and positively correlated when surveys are considered.
- These data are consistent with the following hypotheses about the effect of the sediment variables:
  - Mercury is associated with decreased values of the dependent variables.
  - When survey effects are considered, total sulfides are generally associated with decreased values of the dependent variables.
  - Zinc is associated with increased values of the dependent variables.
  - Small sediment size (less than 5 μ) is associated with increased values of the dependent variables.
- The water data support the general conclusions that
  - Increased salinity generally is associated with smaller values of the dependent variables.
  - Increased dissolved oxygen and turbidity are associated with increased values of the dependent variables.

- Northern stations tend to have less life than the southern stations and, for the disturbed stations to have less life than their undisturbed counterparts.

Many of these relationships are not significant statistically and require careful interpretation, since the effects of unmeasured variables and the interactions among those that were measured do play a role but were not represented in the least-squares equations.

BENTHIC ANIMAL MASTER LIST

PHYLUM PROTOZOA
  Subphylum Ciliophora
    Class Ciliata
      Subclass Euciliata
        Order Peritricha
          Family Vorticellidae
            Vorticella sp.
  Subphylum Plasmodroma
    Class Sarcodina
      Subclass Rhizopoda
        Order Foraminifera
          Unidentified species

PHYLUM PORIFERA
  Unidentified species
    Class Demospongiae
      Unidentified species
        Order Keratosa
          Unidentified species
    Class Hexactinellida
      Unidentified species

PHYLUM CNIDARIA (=COELENTERATA)
  Unidentified species
    Class Anthozoa
      Subclass Alcyonaria (=Octocorallia)
        Order Pennatulacea
          Unidentified species
            Family Stylatulidae
              Stylatula elongata (Gabb, 1863)
      Subclass Zoantharia (=Hexacorallia)
        Order Actinaria
          Diadumene sp.
          Haliplanella sp.

PHYLUM CNIDARIA (=COELENTERATA) (Continued)
- Class Hydrozoa
  - Unidentified species
  - Order Hydroida
    - Suborder Calyptoblastea
      - Unidentified species
      - Family Campanularidae
        - *Campanularia* sp.
        - *Gonothyraea* sp.
      - Family Plumulariidae
        - *Plumularia* sp.
      - Family Sertulariidae
        - *Sertularia* sp.
    - Suborder Gymnoblastea
      - Family Bimeriidae
        - *Bimeria* sp.
      - Family Syncorynidae
        - *Syncoryne* sp.

PHYLUM PLATYHELMINTHES
- Unidentified species
- Class Turbellaria
  - Order ?Acoela
    - Unidentified species

PHYLUM NEMERTEA
- Unidentified species

PHYLUM NEMATODA
- Unidentified species

PHYLUM SIPUNCULA (=SIPUNCULOIDEA)
- *Sipunculus* sp.
- Unidentified species

PHYLUM ANNELIDA
- Class Oligochaeta
  - Unidentified species

PHYLUM ANNELIDA (continued)
Class Polychaeta
Unidentified species
Family Dorvilleidae
Schistomeringos longicornis Jumars, 1974
Schistomeringos sp.
Unidentified species
Family Eunicidae
Lysidice ninetta Audouin and Milne Edwards, 1833
Marphysa sanguinea (Montagu, 1815)
Unidentified species
Family Hesionidae
Gyptis brevipalpa Hartmann-Schroeder, 1959
Hesionella mccullochae Hartman, 1939
Microphthalmus sp.
Ophiodromus pugettensis (Johnson, 1901)
Unidentified species
Family Glyceridae
Glycera americana Leidy, 1855
Glycera oxycephala Ehlers, 1887
Glycera sp., near *robusta* Ehlers, 1868
Glycera tenuis Hartman, 1944
Glycera sp.
Family Goniadidae
Glycinde sp.
Family Nereidae
Neanthes succinea (Frey and Leuckart, 1849)
Neanthes sp.
Nereis latenscens Chanberlin, 1919
Unidentified species
Family Nephtyidae
Nephtys caecoides Hartman, 1938
Nephtys cornuta franciscana Clark and Jones, 1955
Nephtys parva Clark and Jones, 1955

PHYLUM ANNELIDA (Continued)

Family Phyllodocidae

- *Anaitides williamsi* Hartman, 1936
- *Anaitides* sp.
- *Eteone dilatae* Hartman, 1936
- *Eteone lighti* Hartman, 1936
- *Eteone longa californica* Hartman, 1936
- *Eulalia aviculiseta* Hartman, 1936
- *Eumida bifoliata* (Moore, 1909)
- near *Eumida sanguinea* (Oersted, 1843)
- *Eumida* sp.
- *Hesionura* sp.
- *Promystides* sp.
- Unidentified species

Family Polynoidae

- *Harmothoe imbricata* (Linnaeus, 1767)
- *Harmothoe* sp.
- Unidentified species

Family Sigalionidae

- *Pholoe minuta* (Fabricius, 1780)
- *Sthenelanella uniformis* Moore, 1910

Family Syllidae

- *Autolytus* sp.
- *Exogone lourei* Berkeley and Berkeley, 1938
- *Exogone* sp.
- *Langerhansia* sp.
- *Odontosyllis parva* Berkeley, 1923
- *Sphaerosyllis* sp.
- *Streptosyllis* sp.
- *Syllides* sp.
- Unidentified species

Family Capitellidae

- *Capitella capitata* (Fabricius, 1780)
- *Capitella* sp.
- *Capitita ambiseta* Hartman, 1947
- *Decamastus* sp.
- *Heteromastus filiformis* (Claparède, 1864)
- *Heteromastus* sp.
- *Mediomastus californiensis* Hartman, 1944
- *Notomastus (Clistomastus) tennuis* Moore, 1909
- Unidentified species

Family Cirratulidae
- _Caulleriella hamata_ (Hartman, 1948)
- _Chaetozone_ sp.
- _Cirratulus cirratus_ (O. F. Müller, 1776)
- _Cirriformia spirabrancha_ (Moore, 1904)
- _Tharyx parvus_ Berkeley, 1929
- _Tharyx_ sp., cf _monilaris_ Hartman, 1960
- _Tharyx_ sp.
- Unidentified species

Family Cossuridae
- _Cossura pygodactylata_ Jones, 1956

Family Maldanidae
- _Asychis_ sp.

Family Opheliidae
- _Armandia brevis_ (Moore, 1906)

Family Orbiniidae
- _Haploscoloplos pugettensis_ (Pettibone, 1957)
- Unidentified species

Family Oweniidae
- _Myriochele_ sp., near _gracilis_ Hartman, 1955

Family Pectinariidae
- _Pectinaria californiensis_ Hartman, 1941

Family Spionidae
- _Boccardia truncata_ Hartman, 1936
- _Polydora brachycephala_ Hartman, 1936 = _P. caulleryi_ (Mesnil, 1897)
- _Polydora caeca_ Oersted, 1843
- _Polydora ligni_ Webster, 1879
- _Polydora socialis_ Schmarda, 1861
- _Polydora_ sp.
- _Prionospio cirrifera_ Wirén, 1883
- _Prionospio_ sp.
- _Pseudopolydora kempi californica_ Light, 1969
- _Pseudopolydora paucibranchiata_ (Okuda, 1937)
- _Pseudopolydora_ sp.
- _Pygospio_ sp.
- _Scolelepis squamata_ (Mueller, 1806)
- _Spiophanes bombyx_ (Claparède, 1870)
- _Spiophanes fimbriata_ Moore, 1923
- _Spiophanes missionensis_ Hartman, 1941

PHYLUM ANNELIDA (Continued)

Spiophanes sp.
Streblospio benedicti Webster, 1879
Unidentified species

Family Trochochaetidae

Disoma multisetosum Oersted, 1844
Trochochaeta multisetosum Oersted, 1843

Family Terebellidae

Polycirrus californicus Moore, 1909
Polycirrus sp., near *tenuisetis* Langerhans, 1880
Polycirrus sp.
Unidentified species

Family Lumbrineridae

Lumbrineris tetraura (Schmarda, 1861)
Lumbrineris sp.

Family Ampharetidae

Melinnampharete gracilis Hartman, 1969
Unidentified species

Family Sabellidae

Chone gracilis Moore, 1906
Chone mellis (Bush, 1904)
Chone minuta Hartman, 1944
Euchone limnicola Reish, 1959
Unidentified species

Family Chrysopetalidae

Paleanotus bellis (Johnson, 1897)
?*Paleanotus* sp.

Family Pilargiidae

Pilargis sp.

ARCHIANNELIDA

Unidentified species

PHYLUM ARTHROPODA

Subphylum Mandibulata

Class Crustacea

Subclass Ostracoda

Sarsiella zostericola Cushman, 1906
Sarsiella sp.
Unidentified species

PHYLUM ARTHROPODA (Continued)
- Subclass Copepoda
  - Unidentified species
- Subclass Cirripedia
  - Unidentified species
    - Order Thoracica
      - Suborder Balanomorpha
        - Family Balanidae
          - _Balanus cariosus_ (Pallas, 1788)
          - _Balanus crenatus_ Bruguière, 1789
          - _Balanus improvisus_ Darwin, 1854
          - _Balanus_ sp., cf _amphitrite_ Darwin, 1854
          - _Balanus_ sp.
- Subclass Malacostraca
  - Division Peracarida
    - Order Mysidacea
      - Unidentified species
    - Order Cumacea
      - _Cumella vulgaris_ Hart, 1930
      - _Diastylopsis_ sp.
      - _Eudorella pacifica_ Hart, 1930
      - _Eudorella_ sp.
      - _Lamprops_ sp. cf _quadriplicata_ Smith, 1879
      - Unidentified species
    - Order Tanaidacea
      - Suborder Dikonophora
        - Family Paratanaidae
          - _Leptochelia dubia_ (Krøyer, 1842)
    - Order Isopoda
      - Unidentified species
        - Suborder Valvifera
          - Family Idoteidae
            - _Synidotea bicuspida_ (Owen, 1839)
            - _Synidotea harfordi_ Benedict, 1897
            - _Synidotea laticauda_ Benedict, 1897
            - _Synidotea_ sp.
        - Suborder Anthuridea
          - Family Anthuridae
            - Unidentified species

PHYLUM ARTHROPODA (Continued)

Suborder Flabellifera

Family Limnoriidae

Limnoria quadripunctata Holthuis, 1949

Suborder Asellota

Unidentified species

Order Amphipoda

Unidentified species

Suborder Gammaridea

Family Ampeliscidae

Ampelisca milleri Barnard, 1954

Family Corophiidae

Corophium acherusicum Costa, 1857

Corophium insidiosum Crawford, 1937

Corophium sp.

Grandidierella japonica Stephensen, 1938

Photis brevipes Shoemaker, 1942

Photis californica Stout, 1913

Photis sp.

Protomedeia zotea Barnard, 1962

Protomedeia sp.

Family Gammaridae

Melita dentata (Krøyer, 1842)

Melita sp., cf _sulca_ (Stout, 1913)

Melita sp.

Unidentified species

Family Ischyroceridae

Ischyrocerus anguipes Krøyer, 1838

Ischyrocerus sp.

Family Phoxocephalidae

Paraphoxus milleri (Thorsteinson, 1941)

Family Pleustidae

Parapleustes pugettensis (Dana, 1853)

Parapleustes sp.

Family Podoceridae

Dulichia sp.

Podocerus sp.

Family Stenothoidae

Stenothoides sp.

Family Synopiidae

Tiron biocellata Barnard, 1962

PHYLUM ARTHROPODA (Continued)
- Suborder Caprellidea
  - Unidentified species
  - Family Aeginellidae
    - _Caprella_ sp.
    - Unidentified species
- Suborder Hyperiidea
  - Unidentified species

Order Decapoda
- Unidentified species
- Suborder Reptantia
  - Section Brachyura
    - Unidentified species
    - Family Majidae
      - _Pyromaia_ _tuberculate_ (Lockington, 1877)
    - Family Cancridae
      - _Cancer_ _antennarius_ Stimpson, 1856
      - _Cancer_ _jordani_ Rathbun, 1900
      - Unidentified species
    - Family Xanthidae
      - _Rithropanopeus_ _harrisii_ (Gould, 1841)
    - Family Pinnotheridae
      - _Pinnixa_ _franciscana_ Rathbun, 1918
    - Family Grapsidae
      - _Hemigrapsus_ _oregonensis_ (Dana, 1851)
  - Section Anomura
    - Unidentified species
    - Family Callianassidae
      - _Callianassa_ _californiensis_ Dana, 1854
      - _Upogebia_ _pugettensis_ (Dana, 1852)
      - _Upogebia_ sp.
  - Section Carides
    - Family Crangonidae
      - _Crangon_ sp.

PHYLUM ARTHROPODA (Continued)
Subphylum Chelicerate
Class Pycnogonida
Unidentified species
Family Ammothecidae
Lecythorhynchus _marginatus_ Cole, 1904
Class Arachnida
Unidentified species
Order Acarina
Unidentified species
Hydracarina--Unidentified species
Class Insecta
Unidentified species
Class Acari
Order Trombidiformes
Family Halacaridae
Unidentified species

PHYLUM MOLLUSCA
Class Gastropoda
Subclass Prosobranchia
Order Mesogastropoda
Family Rissoidae
Alvinia _californica_ (Bartsch, 1911)
Alvinia _compacta_ (Carpenter, 1864)
Family Caecidae
Fartulum sp.
Family Epitoniidae
Epitonium _tinctum_ (Carpenter, 1864)
Family Calyptraeidae
Crepidula _convexa_ Say, 1822
Crepidula _plana_ Say, 1822
Order Neogastropoda
Family Muricidae
Urosalpinx _cinerea_ (Say, 1822)
Family Melongenidae
Busycon _canaliculatum_ (Linnaeus, 1758)
Family Nassariidae
Nassarius _mendicus_ (Gould, 1850)
Nassarius _obsoletus_ (Say, 1822)

- PHYLUM MOLLUSCA (Continued)
  - Subclass Opisthobranchia
    - Order Pyramidellida
      - Family Pyramidellidae
        - *Iselica ovoidea* (Gould, 1853)
        - *Odostomia* (*Evalea*) cf. *O. deliciosa* Dall & Bartsch, 1907
        - *Odostomia* (*Evalea*) *franciscana* Bartsch, 1917
        - *Odostomia* (*Evalea*) *tenuisculpta* Carpenter, 1864
        - *Odostomia* (*Evalea*) *valdezi* Dall & Bartsch, 1907
        - *Odostomia* (*Menestho*) *fetella* Dall & Bartsch, 1909
        - *Odostomia* (*Evalea*) sp.
    - Order Nudibranchia
      - Unidentified species
- Class Bivalvia (Pelecypoda)
  - Unidentified species
    - Subclass Pteriomorphia
      - Order Mytiloida
        - Family Mytilidae
          - *Adula diegensis* (Dall, 1911)
          - *Modiolus* sp.
          - *Musculus senhousia* (Benson, 1842)
          - *Mytilus edulis* Linnaeus, 1758
      - Order Pterioida
        - Family Ostreidae
          - *Ostrea lurida* Carpenter, 1864
        - Family Anomiidae
          - *Pododesmus* sp.
    - Subclass Heterodonta
      - Order Veneroida
        - Family Montacutidae
          - *Mysella ferruginosa* (Dall, 1916)
        - Family Veneridae
          - *Gemma gemma* (Totten, 1834)
          - *Protothaca staminea* (Contrad, 1837)
          - *Tapes japonica* Deshayes, 1853
          - *Transennella tantilla* (Gould, 1853)
        - Family Petricolidae
          - *Petricola* cf. *P. carditoides* (Contrad, 1837)

Table 26 (Continued)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY					SPECIMEN TOTAL
	SURVEY					
	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	
EXOGONE LOUREI	177	1739	589	882	1030	4417
HAPLOSCOLOPLOS PUGETTENSIS	2	--	--	2	1	5
MARPHYSA SANGUINEA	1	16	5	--	27	49
GLYCINDE SP.	2	6	1	2	22	33
ASYCHIS SP.	19	4	3	40	10	76
PSEUDOPOLYDORA KEMPI CALIFORNICA	1	4	1	47	220	273
NEPHTYS CAECOIDES	1	--	--	--	--	1
SPHAEROSYLLIS SP.	2	104	146	345	257	854
DORVILLEIDAE-UNIDENTIFIED SPP.	1	--	--	--	--	1
THARYX SP.	1	--	--	5	--	6
ETEONE LONGA CALIFORNICA	--	7	2	4	170	183
POLYNOIDAE-UNIDENTIFIED JUVENILE	--	1	--	--	--	1
POLYDORA CAULLERYI	--	4	--	--	--	4
HARMOTHOE IMBRICATA	--	13	--	5	29	47
STREBLOSPIO BENEDICTI	--	30	3	313	2139	2485
POLYDORA LIGNI	--	258	462	175	88	983
POLYCIRRUS SP.	--	2079	4	1	3	2087
DORVILLEA SP.	--	1	--	--	--	1
POLYCHAETA-UNIDENTIFIED SPP.	--	1	--	--	--	1
POLYCIRRUS SP., NEAR TENUISETIS	--	1	--	--	--	1
ETEONE LIGHTI	--	--	1	2	110	113
PYGOSPIO SP.	--	--	1	--	--	1
POLYNOIDAE-UNIDENTIFIED SPP.	--	--	--	2	--	2
TEREBELLIDAE-UNIDENTIFIED SPP.	--	--	--	4	--	4
HARMOTHOE SP.	--	--	--	3	--	3
CAPITELLA SP.	--	--	--	2	1	3
AUTOLYTUS SP.	--	--	--	1	--	1
STREPTOSYLLIS SP.	--	--	--	--	1	1
SYLLIDAE-UNIDENTIFIED SPP.	--	--	--	--	1	1
ARTHROPODA						
COROPHIUM INSIDIOSUM	3	16	1	--	--	20
AMPELISCA MILLERI	339	11553	5994	1975	4165	24026
PYROMAIA TUBERCULATA	1	--	--	--	--	1
OSTRACODA-UNIDENTIFIED SPP.	6	--	--	--	--	6
LEPTOCHELIA DUBIA	1	--	3	1	--	5
COROPHIUM ACHERUSICUM	1	15	--	13	296	325
SARSIELLA ZOSTERICOLA	--	165	183	229	264	842
INSECTA-UNIDENTIFIED SPP.	--	1	--	--	2	3
GRANDIDIERELLA JAPONICA	--	16	31	2	20	69

PHYLUM MOLLUSCA (Continued)
- Family Tellinidae
  - *Macoma acolasta* Dall, 1921
  - *Macoma balthica* (Linnaeus, 1758)
  - *Macoma inquinata* (Deshayes, 1855)
  - *Macoma nasuta* (Conrad, 1837)
  - *Macoma* sp.
  - *Tellina modesta* (Carpenter, 1864)
- Family Solenidae
  - *Siliqua patula* (Dixon, 1788)
  - *Siliqua sloati* Hertlein, 1961
- Order Myoida
  - Family Myidae
    - *Mya arenaria* Linnaeus, 1758
    - *Platyodon cancellatus* (Contrad, 1837)
    - Unidentified species
  - Family Hiatellidae
    - *Hiatella arctica* (Linnaeus, 1767)
  - Family Pholadidae
    - *Zirfaea pilsbryi* Lowe, 1931
- Subclass Anomalodesmata
  - Order Pholadomyoida
    - Family Lyonsiidae
      - *Lyonsia californica* Conrad, 1837
      - *Lyonsia* sp.

PHYLUM ECTOPROCTA (=BRYOZOA)
- Unidentified species
  - Order Cheilostomata
    - Unidentified species
    - Suborder Anasca
      - Unidentified species
      - Family Aeteidae
        - *Aetea anguina* (Linnaeus, 1758)
      - Family Alderinidae
        - *Callopora armata* O'Donoghue, 1926
        - *Callopora* sp.
        - *Tegella armifera* (Hincks, 1880)

PHYLUM ECTOPROCTA (=BRYOZOA) (Continued)

Family Bicellariellidae

Bugula californica Robertson, 1905

Bugula neritina (Linnaeus, 1758)

Bugula sp.

Family Cellariidae

Cellaria mandibulata Hincks, 1882

Cellaria sp.

Family Chapperiidae

Chapperia paluta (Hincks, 1881)

Family Cribrilinidae

Membraniporella sp.

Family Electrinidae

Electra arctica Borg, 1931

Electra crustulenta (Pallas, 1766)

Family Membraniporidae

Conopeum commensale Kirkpatrick and Metzelaar, 1922

Conopeum reticulum (Linnaeus, 1767)

Membranipora membranacea (Linnaeus, 1767)

Membranipora perfragilis (MacGillivray, 1881)

Membranipora villosa Hincks, 1880

Membranipora sp.

Family Scrupocellariidae

Scrupocellaria californica Trask, 1857

Scrupocellaria sp.

Tricellaria occidentalis (Trask, 1857)

Tricellaria ternata (Solander, 1786)

Tricellaria sp.

Suborder Ascophore

Family Cheiloporinidae

Cheilopora praelonga (Hincks, 1883)

Cryptosula pallasiana (Moll, 1803)

Family Hippothoidae

Hippothoa cornuta (Busk, 1852)

Hippothoa hyalina (Linnaeus, 1758)

Family Microporellidae

Microporella californica (Busk, 1856)

Family Phylactellidae

Lagenipora punctulata (Gabb and Horn, 1862)

PHYLUM ECTOPROCTA (=BRYOZOA) (Continued)
Family Schizoporellidae
Schizoporella sp.
Family Smittinidae
Parasmittina trispinosa (Johnston, 1838)
Smittoidea prolifica Osburn, 1952
Family Schizoporellidae
Schizoporella sp.
Order Ctenostomata
Family Vesiculariidae
Bowerbankia gracilis Leidy, 1855
Family Alcyoniidae
Alcyonidium parasiticum (Fleming, 1828)
Alcyonidium polyoum (Hassall, 1841)
Order Cyclostomata
Unidentified species
Family Crisiidae
Crisia maxima Robertson, 1910
Crisia occidentalis Trask, 1857
Filicrisia geniculata (Milne-Edwards, 1838)
Filicrisia sp.

PHYLUM ENTOPROCTA
Family Pedicellinidae
Barentsia sp.

PHYLUM PHORONIDA
Phoronopsis viridis Hilton, 1930
Phoronis sp.
Unidentified species

PHYLUM ECHINODERMATA
Class Holothuroidea
cf *Leptosynapta* sp.
Unidentified species
Class Ophiuroidea
Ophionereis sp.

PHYLUM CHORDATA
  Subphylum Urochordata (=Tunicata)
    Unidentified species
      Class Ascidiacea
        Unidentified species
          Order Enterogona
            Suborder Aplousobranchia
              Amoroucium sp.
            Suborder Phlebobranchia
              Ciona intestinalis (Linnaeus, 1767)
          Order Pleurogona
            Suborder Stolidobranchia
              Styela sp.

  Subphylum Vertebrata
    Class Osteichthyes
      Unidentified species

LITERATURE REVIEW

Previous Studies of San Francisco Bay

Several benthic surveys have been conducted in San Francisco Bay, most of them within the past 20 years. These studies reflect man's concern about the effects he produces on valuable natural resources (U.S. House Committee on Government Operations, 1969, 1970). Such effects can be economic, the declining fish and shellfish resources being an example (Skinner, 1962). As man becomes more aware of the intricacies of the marine environment, his concern increases about the effects of pollution on marine life (Daniels and Chadwick, 1971). There is also aesthetic concern for the Bay as a valuable recreation area and practical concern for climate and air pollution in the Bay Area (Miller, 1970).

Although pollution undoubtedly affects the marine life of San Francisco Bay, natural environmental variables such as depth, substrate, temperature and salinity, and season also affect marine populations (Emergy and Stevenson, 1957; Carriker, 1967). A significant feature is the inflow of the Sacramento and San Joaquin Rivers into the north San Francisco Bay estuary. These rivers carry fresh water, silt, nutrients, and pesticides into the bay and help to flush pollutants out the Golden Gate. In contrast, currents in the South Bay result largely from tides, and freshwater inflow is primarily from waste discharges (McCarty et al., 1961).

Comparing the results of previous San Francisco Bay studies is difficult because sampling methods have not been standardized. A number of benthic sampling devices have been employed in benthic studies (e.g., the Petersen, van Veen, Ekman, Smith-McIntyre, and orange peel dredges and the beam and sledge trawls), some of which are available in more than one size. These samplers differ in the amount of area they can sample, in their depth of penetration,

and in the efficiency of their operation under different conditions of depth, current, and substrate (Gunter, 1957; Thorson, 1957; Hopkins, 1964; American Public Health Association et al., 1971; Holme, 1971; McIntyre, 1971b). Thus, there may be qualitative and quantitative differences in the organisms collected. In addition, the size of the screen through which the sample is washed greatly affects the number of species, the number of individuals and the biovolume recovered (Reish, 1959; Birkett and McIntyre, 1971).

The frequency of sampling and the number of replicates also influence population statistics because of the nonrandom distribution, such as underdispersion or overdispersion, of many benthic invertebrates (Elliott, 1971). The large variances of replicate samples found in our study and other studies (Painter, 1966; McErlean et al., 1972) are evidence for the need for replicate sampling. If the variability in sampling is not estimated, differences in populations attributed to location, time, or environmental factors may well be due to sampling error. A number of authors have employed various statistical procedures to determine the number of samples required to represent adequately the total number of species present (Jones, 1961; Storrs et al., 1966a; McIntyre, 1971a).

Studies conducted in different seasons or years are also difficult to compare because of variations both in physical factors, such as temperature, salinity, turbidity, and in biological factors, such as the life histories of the organisms. Finally, comparison of species lists reported in San Francisco Bay studies is limited by the taxonomic capabilities of the personnel making identifications (Hedgpeth, 1970; Carlton, 1972). A trained taxonomist is required to identify San Francisco Bay organisms, because many organisms have been introduced from other areas of the world with oyster transplants or in bilge water from ships. Nichols (1973) has written a particularly detailed critical review of the methodology and limitations of previous San Francisco Bay surveys.

Despite their limitations, the previous San Francisco Bay benthic surveys did provide some qualitative background information for our study. Accordingly, the previous surveys will be

discussed with the following areas of emphasis: a comparison of our study areas with those of other studies; the association of locations within these areas with the greatest numbers of species and individuals; the kinds and numbers of the more common animals collected for various seasons; and the relationships of environmental factors such as depth, salinity, temperature, and substrate type to species distribution.

The first extensive benthic study of San Francisco Bay was made during 1912-13 by the Federal Bureau of Fisheries using the steamer Albatross to survey the fisheries resources of San Francisco Bay (Sumner et al., 1914). These investigators studied physical characteristics of the Bay such as tidal range, current velocity, depth, and bottom type. Trawl and dredge samples were taken for counting organisms at 149 dredging stations, whereas water samples were taken for measuring temperature and salinity at 322 hydrographic stations from Suisun Bay to the southern tip of San Francisco Bay, primarily in the tidal channels. The species collected from these studies were reported in several papers by various authors. Packard reported on the molluscs (1918a,b), Schmitt on the crustaceans (1921), and Hartman on the polychaetes (1954).

Packard (1918a), dealing first with only the molluscs collected by the orange peel dredge from Carquinez Strait to south San Francisco Bay, made somewhat quantitative comparisons between areas. He listed 35 species consisting of 23 pelecypods and 12 gastropods. Ten of these species were found at more than one-fourth of the stations. The richest area in numbers of species, individuals, and old shells was the middle division (from an imaginary line from Point San Pedro to Point San Pablo to a line from the Ferry Building to Goat Island Light); the second richest was the lower division (south of that line); and the third richest area was the upper division (San Pablo Bay). Because of the limited number of samples (43), Packard could not specify the species to be expected in those areas. The productive middle division was characterized by the deepest depths (15-20 fathoms), salinities of 28-30 ‰, lowest annual mean temperature, lowest seasonal temperature range, and largest plankton populations. He considered

salinity to be the most important factor influencing the distribution of organisms. The importance of temperature was unclear, but Packard suggested that its greatest effect would be on the larvae of the organisms. Whereas most species were found on several substrates, a few species could be described tentatively as characteristically mud- or sand-dwelling organisms. A substrate of sand and shells supported the largest number of species and individuals of molluscs.

Packard's second paper (1918b) dealt qualitatively with all species of molluscs collected in the Albatross survey. Eighty-one species were collected, slightly over half of them pelecypods. For each species, Packard gave a physical description, the range, and the stations of collection. Again, he considered environmental factors in distribution, and his earlier conclusions were confirmed with one exception. A substrate of mud rather than sand and shell was found to support the most molluscs.

In his extensive monograph on decapod crustacea, Schmitt (1921) listed for each Albatross dredging and hydrographic station the date, depth, bottom type, sampling method, and the decapod crustaceans collected; however, he did not discuss the data.

Hartman (1954) later published a species list of polychaetes from San Francisco Bay, many of which were first reported for the Bay from the Albatross expedition. Station numbers from the Albatross expedition, published records for San Francisco Bay, and bibliographic citations were given for each species, but the abundances, distributions, seasonal variations, or relationships to environmental factors were not discussed. Other species from the Albatross expedition have been reported on by other authors, Treadwell (1914) being one.

After the Albatross expedition, the next sampling in San Francisco Bay was not conducted until Filice surveyed the Castro Creek area from April to December 1951 (Filice, 1954a). He worked on the premise, earlier suggested by Patrick (1950) for freshwater environments, that the health of an area can be assessed best by the well-being of its benthic fauna, since the benthos--a valuable food source for other organisms--cannot escape pollution.

In a preliminary study, Filice compared the fauna of Castro Creek marsh, washed by both industrial and domestic wastes, with relatively unpolluted Galinas Greek marsh across San Pablo Bay; he found several more species in the latter area. He then sampled 85 stations near Castro Creek. One sample was collected with a Petersen dredge in deeper areas, and three pooled samples were collected with an Ekman dredge in shallower areas. Filice found a close correlation between current flow from Castro Creek and lack of bottom invertebrates, which he attributed to the toxicity of the wastes. Other environmental factors were not considered. On either side of this impoverished area, few species were present, but he found a greater-than-normal volume of animals. Filice suggested that the increased volume of animals at the edges of the impoverished area was due to the success of a few tolerant species in an area of enrichment with few competitors.

To test the validity of these conclusions, Filice sampled 375 stations extending from San Pablo Bay to Antioch on the San Joaquin River between September 1951 and April 1952. The most numerous species collected were, in order of decreasing abundance, *Gemma gemma*, *Balanus improvisus*, *Mya arenaria*, *Polydora uncata*, *Nereis succinea*, and *Macoma inconspicua*. However, the most widely distributed species were *N. succinea* and *G. gemma*, followed by *M. inconspicua*, *Nassarius obsoletus*, and *B. improvisus*. Filice found only minor differences between his species list and the lists from the Albatross expedition; he attributed these differences to sampling error. In agreement with his earlier findings, Filice found that most stations had low volumes of animals (Filice, 1954b) and few specimens of each species (Filice, 1958). As reported by Packard (1918b), the volume of animals (Filice, 1954b) and the number of species (Filice, 1958) were greater in seaward areas and on mud substrates than on sand. Filice reported a "faunal break" in the eastern half of Carquinez Strait with an average salinity of 9.5 ‰, the species seaward and riverward being quite different. Filice listed the following pollution categories in order of increasing number of species: industrial outfalls, domestic outfalls, marginal to industrial outfalls, and normal bottom. The densities of organisms paralleled the number of species with the exception of marginal to domestic outfalls, which had a large abundance of a few tolerant species that presumably thrived, in the absence of more sensitive competitors, on the increased organic matter from domestic waste (Filice, 1959).

Filice also described the distribution and abundance of each of the 53 species collected, especially in relation to salinity, depth, and substrate.

At about the same time, in October 1953, Brown and Caldwell Engineers surveyed 27 stations near Coyote Creek south of the Dumbarton Bridge to study the effects of waste discharges on benthic organisms (Brown and Caldwell Engineers, 1954, in Nichols, 1973). According to Nichols (p. 4), "Although the data on benthic organisms were limited, the scarcity of animals in Coyote Creek above Gray Goose Slough was suggested as evidence of a toxic environment."

In the same year, Jones surveyed the fauna off Point Richmond (California Department of Public Health, 1954, in Nichols, 1973). Jones sampled each of 65 stations once in September with an Ekman dredge and identified and counted subsamples of organisms. Nichols (p. 4) stated, "Because of the lack of replicate sampling ... and the few environmental and pollution parameters measured, the report could conclude only that waste discharges had little noticeable effect on the benthos near Point Richmond."

Jones again studied the benthos near Point Richmond during 1954-55 for his Doctoral thesis research (Jones, 1961). Using a core sampler with an area of 2.5 cm^2, he first took 50 replicate samples at a station to determine the number of samples needed to estimate the total number of species. He concluded that 30 samples would be sufficient. Jones then collected 30 replicate samples at each of four stations at about six-week intervals between January 1955 and March 1956. Beginning with the fourth collection period, he also took one Ekman dredge sample per station for comparison of techniques. Two of the stations were similar except for coarseness of substrate. The faunas at these two stations were basically similar but differed in the densities of different species. Jones found that the biomass collected at the station with fine substrate was greater than that with coarse substrate, an observation consistent with the findings of Filice (1954b). The species diversities did not differ significantly. The other two stations were similar to one another except for their depth and the compactness of their substrate. The faunas differed somewhat at the

two--Sphaerosyllis pirifera and Streblospio benedicti predominating at the shallower station, Tharyx parvus and Cossura pygodactylata predominating at the deeper station. Biomass was greater at one station for part of the year and greater at the other station the remainder of the year. From all stations, more than 70 species were collected, most of them found in small numbers and/or on few occasions. The animals found most consistently at all stations were Sphaerosyllis pirifera, Tharyx parvus, Cumella vulgaris, and three species of oligochaetes. Jones followed the fluctuations in dispersion patterns for 19 of the species. Four were generally aggregated, one was never aggregated, and the remaining species generally were dispersed randomly. Comparing the results from the two kinds of sampling devices, Jones concluded that larger samplers are needed to estimate density and that smaller ones are required to study distributional patterns.

South San Francisco Bay was studied again in 1957 when the California Department of Fish and Game conducted a survey in August and September (Pintler, 1958). One sample was collected with an Ekman dredge at each of 24 stations, and three samples each were collected at two stations in Mowry Slough. Pintler reported a total of 22 "kinds" of live organisms, nearly a third of them oligochaetes and over half of them molluscs (predominantly Macoma clams). Like Brown and Caldwell Engineers (1954), he found fewer organisms upstream in Coyote Creek than downstream from a polluted area, with a few species occurring in large numbers.

In 1958, a preliminary study of San Francisco Bay was begun south of Dumbarton Bridge (Harris et al., 1961) by the Sanitary Engineering Research Laboratory (SERL) of the University of California at Berkeley, sponsored by the California State Water Resources Control Board. This study was expanded to investigate the entire San Francisco Bay, with the objective of developing a quantitative description of the biota of San Francisco Bay and of the relationships of organisms to physical and chemical factors, sediment type, and waste discharges (Storrs et al., 1966a,b; Pearson et al., 1970). The Bay was divided into six study areas, three of which were studied in each of four years (McCarty et al., 1961; Storrs et al., 1963a,b, 1964a,b, 1965 a,b). Two samples were collected from 6 to 10 stations in each study area every one

or two months. Before 1962, the two samples were processed separately, but later they were processed together. To compensate for loss of variability after the samples were combined, 5 to 10 replicates were taken at selected stations. SERL calculated that, with 10 replicates, about 95% of the total number of species at that location had been collected. In addition, with six to seven replicates, 90% of the species collected in 10 replicates would be found.

The total benthic animal biovolume of the Bay consisted of 70% molluscs, 25% annelids, and 5% arthropods. On the basis of biovolume, the dominant molluscs were: *Tapes semidecussata* south of Hunters Point; *Macoma nasuta* from Hunters Point to Point San Pablo; *Modiolus senhousei* and *Tapes semidecussata* in San Pablo Bay; and *Corbicula fluminea* and *Mya arenaria* in Suisun Bay. The dominant arthropods were *Corophium insidiosum* and *Photis californica* in the South Bay, *Corophium spinicorne* and *Balanus* sp. in Suisun Bay, and *Photis californica* in the central regions. Finally, the dominant annelids were *Neanthes succinea* and *Polydora uncata* in Suisun Bay, *Glycinde armigera* in San Pablo Bay, and *Glycinde armigera* and *Asychis amphiglypta* from Hunters Point to the San Mateo Bridge. In the other areas of the Bay, no one annelid species contributed to more than 50% of the biovolume. Consistent with the findings of Packard (1918a) for molluscs, benthic biovolume and species diversity (based upon number of species and frequency of occurrence) were greatest in the more saline Central Bay. Only in the extreme southern end of the Bay did benthic diversity change with season, being lowest in fall and winter and highest in mid-summer.

Brinkhurst and Simmons (1968) later identified some of the oligochaetes collected during the SERL study. The data were too few to compare stations and seasons. In the highly polluted southern tip of San Francisco Bay, types of organisms and individuals were few, but the proportion of oligochaetes was high. The extremely depressed fauna of Redwood City Creek was suggested to be a result of local pollution, especially since Storrs et al (1963a), found high levels of heavy metals in that creek.

Also in the early 1960s, Dederian (1966) surveyed the benthic fauna of the San Francisco waterfront from the Bay Bridge to

Hunters Point. Each of the 147 stations was represented by a single sample taken with a modified Petersen dredge. The most numerous species collected was *Transennella tantilla*, followed by--in order of decreasing abundance--*Photis brevipes*, *Pectinaria californiensis*, *Macome nasuta*, and *Macoma inquinata*. The known ecological distribution of each species was discussed.

At about the same time, the California Department of Fish and Game undertook an ecological study of the Sacramento-San Joaquin Rivers estuary as a part of the Delta Fish and Wildlife Protection study (Kelley, 1966). Painter (1966) reported on the zoobenthos of San Pablo and Suisun Bays collected at 27 stations monthly throughout 1963 with a Petersen dredge. The mesh size of the screen was changed in the second half of the study from 50 to 30 meshes per inch to allow more time for collection of three replicates per station instead of two. More than 40 taxa were reported. The 11 most "important" animals collected were the lamellibranchs *Tapes semidecussata*, *Gemma gemma*, *Macoma inconspicua*, and *Mya arenaria*; the crustaceans *Photis californica*, *Corophium* spp., and *Synidotea laticauda*; and the polychaetes *Neanthes succinea*, *Glycinde armigera*, *Streblospio benedicti*, and *Polydora uncata*. Painter discussed the distributions of these species relative to chlorinity, sediment type, depth, and location. The effects of depth and substrate could not be spared. Chlorinity was the major environmental factor affecting distribution. Like Filice (1958), Painter reported a distinct faunal break in eastern Carquinez Strait.

As another part of the Department of Fish and Game study, Hazel and Kelley (1966) described the zoobenthos of the Sacramento-San Joaquin Delta. They sampled 25 stations monthly in 1963 with a Petersen dredge, collecting one sample per station. Although they collected 35 taxa of animals, the only abundant organisms were the clam *Corbicula fluminea* and the amphipods *Corophium spinicorne* and *C. stimpsoni*. Hazel and Kelley discussed the distributions of the common species with respect to substrate type. Like Packard (1918b) and Filice (1954b, 1958), Hazel and Kelley found that sand supported the least life. Seasonal variations in species distributions were not discussed.

Literature Review
Previous Studies of San Francisco Bay

The California Department of Fish and Game also conducted a biological survey of the Bay from the San Rafael Bridge to south of the Dumbarton Bridge (Aplin, 1967). Each month in 1963, one sample was collected with an orange peel dredge from each of six stations. Invertebrates also were collected in the fish trawl nets. Although the data were not quantitative, the polychaete Asychis amphiglypta and the bivalves Musculus senhousei, Tapes semidecussata, and Gemma gemma were common. For each species, the stations and sometimes the substrate type from which it was collected were given.

In 1969, as a part of the San Francisco Bay Delta Water Quality Control Program, commissioned by the State Water Resources Control Board, the Kaiser Engineers reported on surveys performed by them and the California Department of Fish and Game (Kaiser Engineers, 1969). The latter study was a survey of shellfish populations conducted along the entire San Francisco Bay shoreline from June through December 1967. The most abundant clams were Mya arenaria and Tapes semidecussata, the former about three times more numerous than the latter. The life histories and environmental requirements, including salinity, temperature, substrate, and dissolved oxygen, of these two species and of mussels and oysters were reviewed (California Department of Fish and Game, 1968).

To update the SERL study, the Kaiser Engineers sampled 20 of the SERL stations throughout San Francisco Bay in March 1968. Two to four orange peel dredge samples were combined for each station. The dominant groups found were annelids, arthropods, and molluscs. The number of species in the South Bay was about half that of the North Bay, and the species diversity (based on the number of species and their relative abundances) was even less than half. As reported by Packard (1918a) and Storrs et al. (1966b), the Kaiser Engineers found the greatest diversity of species in the more saline Central Bay. Regression analysis was used to derive a formula relating species diversity to chlorosity and percentage of sand.

In 1967, Vassallo studied the intertidal Macoma inconspicua (M. balthica) community on the eastern shoreline of San Francisco Bay just north of the San Mateo Bridge (Vassallo, 1969, 1971).

He sampled 63 stations in three transects once with a homemade core sampler approximately 0.01 m^2 in area and 21 cm in height. M. inconspicua dominated the higher intertidal, and the amphipod Ampelisca milleri predominated in the lower intertidal. Vassallo discussed the possible ecological relationships of the two. M. inconspicua was distributed uniformly to a depth of 25 cm, and A. milleri (tubes) was distributed to a depth of 2.5 cm.

The U.S. Fish and Wildlife Service conducted a study of the effects of dredging on fish and invertebrates (except polychaetes) from Carquinez Strait to the San Rafael Bridge (U.S. Fish and Wildlife Service, 1970). Seventeen stations were sampled monthly for all or part of the period from September 1967 to August 1969. The sampling device and the number of samples were not specified. No difference was reported in the number of species of benthic organisms between dredged and undredged areas, but abundances were lower in the dredged areas. The exclusion of polychaetes from the study may affect these conclusions. Some relationships between abundances of organisms and season, depth, chlorosity, and sediment were discussed, but no supportive data were presented. Kinds and numbers of organisms increased with depth and salinity.

Brown and Caldwell Engineers, commissioned by the City of San Francisco to study possible locations for waste outfalls, sampled five stations in San Francisco Bay near Alcatraz in June and October of 1970 (Brown and Caldwell Engineers, 1971). A minimum of two samples per station were collected with a Petersen or orange peel dredge. Brown and Caldwell Engineers combined its data with those collected six years earlier on the continental shelf around the mouth of the Bay by the Hydraulic Engineering Laboratory of Berkeley (Yancey and Wilde, 1970), although the data were collected by markedly different methods. Brown and Caldwell Engineers described four communities--shelf, near reef, bar, and Bay--and concluded that sediment type and degree of wave exposure were the most important factors in determining community composition.

South San Francisco Bay was studied again in 1966 by Wilde (1969), who sampled the macrofauna in the mouth of Plummer Creek from March through September. He constructed a hardware mesh fence across the creek with a large net bag in the center. Fish

and invertebrates were channeled into the net on the outgoing tide. More than 6,000 invertebrate specimens were collected, representing 10 species. These included three molluscs, four arthropods, and no polychaetes. The most abundant organism by far was the bay shrimp *Crago franciscorum*. Few burrowing animals were collected, as would be expected by the sampling method.

Allen (1971) surveyed the benthic invertebrates in Castro Creek. Three to seven samples were taken with an Ekman dredge at each of 23 stations. Like Pintler (1958) and Brown and Caldwell Engineers (1954), Allen found that biovolume increased toward the mouth of the creek. With one exception, only annelids, arthropods, and molluscs were collected.

Also south of the Dumbarton Bridge, Burton (1972) sampled 45 stations from July through August 1971. He used an Ekman dredge to collect five samples along a transect at each station. Sulfide content of the sediment was determined in the laboratory. A statistically significant correlation existed between high sulfide concentrations of the sediment and low species diversities calculated by the Shannon-Weiner function. Thirty species of invertebrates were identified. The most numerous in decreasing order were *Gemma gemma*, *Ampelisca* sp., *Macoma inconspicua*, and *Aorides* sp.

The Effects of Heavy Metals on Marine and Estuarine Invertebrates

General Sources of Heavy Metals in Aquatic Systems

A large number of heavy metals are natural constituents of aquatic environments, originating from the weathering of metal-bearing rocks and soils (Leland et al., 1974). The metals can be transported to the aquatic environment by air, surface water, and ground water, and natural levels may be increased by the activities of man (suggested by the observation of Bruland and coworkers, 1974, who found that the rate of accumulation of zinc, copper, cadmium, and lead in coastal sediment deposits is much faster today than a century ago).

Copper, cadmium, lead, zinc, and mercury--the metals of concern in this study--have a large number of agricultural and industrial applications, and effluents from manufacturing plants that use these metals are a prime source of environmental contamination. Other known sources are power plants, mines, nuclear fallout, and smelters (Leland et al., 1974), domestic sewage (Halcrow et al., 1973), water pipes, and the use of agricultural products containing these metals.

Copper may be dissolved from rocks by natural waters (Prytherch, 1934); however, a considerable amount of copper in aquatic systems may come from agricultural and industrial sources. Metallic copper is used in many alloys in the manufacture of cooking utensils, pipes, roofing material, and electrical wires (McKee and Wolfe, 1963). Copper salts are used in the manufacture of textiles, pigments, leather, and pesticides and in photography, engraving, and electroplating.

Cadmium is a natural impurity often found in zinc-lead ores; its many industrial applications include electroplating, photographic processing, and manufacturing of paint and pesticides (McKee and Wolfe, 1963).

Lead also may occur naturally in water, especially in locations having mountain limestone and galena (McKee and Wolfe, 1963). Lead is used commonly as an antiknock agent in gasoline, exiting as automobile exhausts to be washed by rain into the aquatic environment.

Because elemental mercury is relatively inert chemically, it is not likely to occur as a water pollutant. However, its salts are highly soluble in water and, along with organic mercury compounds, are the most likely metals to cause pollution problems. Although mercuric salts occur in nature principally as the sulfide (cinnabar), numerous synthetic organic and inorganic salts are used in industrial processes and in the manufacture of commercial products (McKee and Wolfe, 1963).

Zinc commonly is used in electroplating and in manufacturing printing plates, dyes, and electrical products. Its salts are used in pigments, cosmetics, pharmeceutics, insecticides, and many other commercial products. Zinc also occurs naturally in rocks and metal ores (Leland et al., 1974).

Point Sources of Heavy Metals in San Francisco Bay

In 1969, Pearson and associates of SERL compiled an inventory of waste dischargers in San Francisco Bay as part of an extensive investigation of the water and sediment quality of the Bay (Pearson et al., 1969). The SERL report listed numerous point sources of heavy metals for Suisun Bay and the lower San Joaquin River. The Sacramento-San Joaquin River System, which enters San Francisco Bay via Suisun Bay, drains much of northern California and undoubtedly carries large amounts of industrial, municipal, and agricultural wastewaters into the Bay.

Pearson and associates also estimated the average daily mass-emission rates of heavy metals for municipal and industrial point sources to the Bay during 1961-64. Table 58 presents these rates.

Surface runoff is another relatively large source of heavy metals for the Bay. According to a study performed by the URS Research Company (1974), the estimated annual amounts of copper, lead, and zinc washed off the streets of the city of Vallejo, located along the eastern shore of Mare Island Strait, are 1,900, 43,000, and 8,700 pounds, respectively. According the URS report, the estimated mean annual concentrations of heavy metals in storm water runoff from a typical city, typical industrial area, and typical marina are, respectively, 0.07, 0.24, and 0.36 mg/liter for copper; 1.2, 4.5, and 6.6 mg/liter for lead; and 0.26, 0.95, and 1.3 mg/liter for zinc.

Table 58

MASS EMISSION RATES OF HEAVY METALS FOR MUNICIPAL AND INDUSTRIAL DISCHARGERS IN SAN FRANCISCO BAY AREAS

Area and Type of Discharge	Heavy Metals (pounds/day)
South San Francisco Bay	
Municipal	2,024
Industrial	205
Total	2,229
Suisun-Lower San Joaquin River	
Municipal	1,502
Industrial	10,653
Total	12,155
San Pablo Bay	
Municipal	430
Industrial	5,654
Total	6,084
North San Francisco Bay	
Municipal	719
Industrial	234
Total	953
Central San Francisco Bay	
Municipal	1,163
Lower San Francisco Bay	
Municipal	124
Industrial	26
Total	150

Source: Pearson et al., 1969.

Toxicity of Heavy Metals to Benthic Organisms

Tables 59 to 63 summarize toxicity data for copper, cadmium, lead, zinc, and mercury. These data were derived from laboratory experiments performed by a number of investigators on genera reported for San Francisco Bay. Experimental conditions and other details of each study are not presented in the tables but may be obtained by consulting the original articles.

The data presented in the tables indicate that, when present in ionic form, the five heavy metals can be highly toxic to marine and estuarine benthos. All the metals can produce toxic effects at concentrations less than 1 ppm, depending on the species and age of the animal tested. With the exception of cadmium and mercury, we found that the concentration of heavy metals in the sediment collected from the seven dredging and disposal areas in San Francisco Bay was much greater than the average ionic concentrations reported to be toxic to benthic animals.

Assessing the potential toxicity of metals contained in the sediments in San Francisco Bay is difficult based only on the concentration of the metals. Largely, toxicity dependes on the availability of the metals to the organisms, and availability depends on a diversity of complex factors. Furthermore, toxicity data obtained in the laboratory must be extrapolated cautiously. Most laboratory studies are performed under static test conditions under which changes may occur in the concentration and form of the metal because of adsorption to the test container or because of changes in the quality of the test medium resulting from metabolic activities of the animals. Even so-called long-term studies are short relative to the life span of some benthic species. Laboratory studies provide toxicity data that apply only to the species of animal tested and to the degree conditions of the study.

The degree of toxicity of a given heavy metal may be influenced not only by the availability of that metal but also by the form of the metal, the temperature and salinity of the water, the type of sediment, and the presence of particulate matter.

Table 59

TOXICITY OF COPPER TO MARINE AND ESTUARINE INVERTEBRATES

Species	Test Duration	Concentration (mg/liter)	Results	Reference
Mollusca				
Oyster (sp. unspecified)	96 hr	1.0	100% survival	Fujiya, 1960
	96 hr	1.9	50% mortality	
	96 hr	3.4	100% mortality	
Crassostrea gigas				
Embryos	42-48 hr	0.08	100% survival	Calabrese et al., 1973
	42-48 hr	0.103	50% mortality	
	42-48 hr	0.13	100% mortality	
	--	0.01-0.032	No effect	Okubo and Okubo, 1962
	--	0.1	Development inhibited	
Crassostrea virginica	20 wk	25, 50	10-15% mortality	Shuster and Pringle, 1969
Ostrea virginica				
Presetting larvae	3-5 min	3-20	100% mortality	Prytherch, 1934
Setting larvae	--	<0.5	No effect on setting	
Setting larvae	Few days	0.8-1.5	Lethal after setting	
Mytilus edulis				
Embryos	--	0.032	No effect on development	Okubo and Okubo, 1962
	--	0.1	Development inhibited	
Adults	--	500	Reduced oxygen uptake	Brown and Newell, 1972
	14 days	0.1	5% mortality, 7 days	Scott and Major, 1972
	14 days	0.2	Respiration and heart rate unaffected, 55% mortality, 7 days	
Mytilus edulis planulatus				
Larvae	--	22.2	50% mortality, 2 hr	Wisely and Blick, 1967
Mytilus californianus	60 days	0.10	100% survival	Marks, 1938
	60 days	0.15	Survived 30 days	
	60 days	0.20	Survived less than 2 days	
Mya arenaria	--	>0.02	Extremely toxic	Pringle et al., 1968
Paphia staminea	65 days	1.0	100 alive at 30 days Initial number not given	Marks, 1938

Table 59 (Continued)

Species	Test Duration	Concentration (mg/liter)	Results	Reference
Polychaeta				
Polychaetes (7 spp.)	96 hr	0.15-0.96	50% mortality	Reish, 1974
	28 days	0.03-0.65	50% mortality	
Nereis diversicolor	888 hr	0.1-0.7	41-828 hr mean survival time (from low-Cu area)	Bryan and Hummerstone, 1971
	888 hr	0.1-0.7	247-888 hr mean survival time (from high-Cu area)	
	408 hr	0.25-2.5	18-140 hr mean survival time (from low-Cu area)	
	408 hr	0.25-2.5	16-150 hr mean survival time (from low-Cu area)	
	408 hr	0.25-2.5	50-408 hr mean survival time (from high-Cu srea)	
Nereis virens	21 days	<0.1	100% survival	Raymo..t and Shields, 1963
	21 days	0.1	Toxicity threshold	
	21 days	0.4-0.5	100% mortality, 7 days	
	25 hr	0.18	Respiration rate increased 40%	
	4 days	0.18	Respiration rate increased >100%	
Oligochaeta				
Nais sp.	--	1.0-2.0	Lethal, 24 hr	Learner and Edwards, 1963
Limnodrilus hoffmeisteri	--	0.40	96-hr TLm (hard water)	Wurtz and Bridges, 1961
	--	0.38	24-hr TLm (hard water)	
Ectoprocta				
Bugula neritina (larvae)	--	<0.2	Decreased growth and development	Miller, 1946
	--	0.2-0.3	Decreased growth and development	
	--	>0.3	Decreased growth, larval death	
	--	3.8	50% larval mortality, 2 hr	Wisely and Blick, 1967

Table 59 (Continued)

Species	Test Duration	Concentration (mg/liter)	Results	Reference
Ectoprocta (Continued)				
Bugula sp.	48 hr	0.5	Survived, 3.7 hr	Riley, in Ketchum, 1952
	5 hr	<0.5	100% mortality	
Arthropoda				
Artemia salina				
Adults	94 hr	150-500	50% mortality in 35-94 hr	Corner and Sparrow, 1956
	94 hr	500-1000	50% mortality in 20-35 hr	
	4.5 hr	1.0	Motility and respiration reduced to 95% and 73% of normal	
	24 hr	0.68-1.04	50% mortality	Okubo and Okubo, 1962
	Various	1.0	50% mortality in 168 hr	Brown and Ahsanullah, 1971
Larvae	Various	1.0	50% mortality in 110 hr	
Crangon crangon				
Larvae	--	0.33	50% mortality, 54 hr	Connor, 1972
	--	3.3	50% mortality, 2.8 hr	
	--	33.0	50% mortality, 0.22 hr	
Adults	48 hr	32	50% mortality, 48 hr	Portmann, 1968
Cancer irroratus	48 hr	>5.0	Mortality, % unspecified	Thurberg et al., 1973
	48 hr	0.6	Osmoregulation abolished	
Balanus amphitrite (cyprids)	1 hr	0.5, 1.5	Increased oxygen uptake	Bernard and Lane, 1963
	--	10-500	Progressive decrease in oxygen uptake	
	--	100-200	Survival time reduced	
	--	>50	Activity reduced	
Balanus balanoides	2 hr	10	Almost 100% mortality	Muller, 1940
Nauplii	2 hr	30	Almost 100% mortality	
Cyprids	3 hr	50	Some mortality	
Balanus crenatus	2 hr	10	Almost 100% mortality	Muller, 1940
Balanus amphitrite	--	3.2	No effect	Okubo and Okubo, 1962

Table 59 (Concluded)

Species	Test Duration	Concentration (mg/liter)	Results	Reference
Arthropoda (Continued)				
Balanus balanoides				Pyefinch and Mott, 1948
Nauplii	6 hr	0.41	50% mortality	
Cyprids	6 hr	5.9	50% mortality	
Settling cyprids	7-8 days	0.01	Settling prevented	
Metamorphosing cyprids	39 hr	0.01-10.0	Metamorphosis unaffected	
Juveniles	--	0.01-10.0	Calcification prevented	
Adults	24 hr	0.32	50% mortality	
Balanus crenatus				Pyefinch and Mott, 1948
Nauplii	6 hr	0.26	50% mortality	
Cyprids	6 hr	7.0	Less than 50% mortality	
Metamorphosing cyprids	24 hr	0.5-7.5	Metamorphosis unaffected	
Juveniles	--	0.5-7.5	100% mortality	
Adults	24 hr	0.19	50% mortality	

Table 69

TOXICITY OF CADMIUM TO MARINE AND ESTUARINE INVERTEBRATES

Species	Test Duration	Concentration (mg/liter)	Results	Reference
Mollusca				
Crassostrea gigas Embyros	42-48 hr	1.0 3.8 6.0	100% survival 50% mortality 100% mortality	Calabrese et al., 1973
Crassostrea virginica	20 wks	100, 200	84-100% mortality	Shuster and Pringle, 1968
Ostrea sinucta	--	50	Close to toxic limit	Brooks and Rumsby, 1967
Mya arenaria	96 hr	2.2	50% mortality	Eisler, 1971
Urosalpinx cinerea	96 hr	6.6	50% mortality	Eisler, 1971
Nassarius obsoletus	96 hr	10.5	50% mortality	Eisler, 1971
Mytilus edulis	96 hr	25.0	50% mortality	Eisler, 1971
Polychaeta				
Polychaetes (4 spp.)	96 hr	5.9-21.0	50% mortality	Reish, 1974
Polychaetes (3 spp.)	28 days	0.7-6.4	50% mortality	Reish, 1974
Nereis diversicolor	816 hr 816 hr	1-100 1-100	233-816 hr mean survival time (from low-Zn area) 187-816 hr mean survival time (from high-Zn area)	Bryan and Hummerstone, 1973 Bryan and Hummerstone, 1973
Nereis virens	96 hr	11.0	50% mortality	Eisler, 1971
Arthropoda				
Artemia salina	Various	1.0	50% mortality, 240 hr	Brown and Ahsanullah, 1971
Crangon septemspinosa	96 hr	0.32	50% mortality	Eisler, 1971
Pagurus longicarpus	96 hr	0.32	50% mortality	Eisler, 1971
Cancer irroratus	48 hr	>1.0 0.12-1.00	Some mortality Reduced oxygen consumption	Thurberg et al., 1973

Table 61

TOXICITY OF LEAD TO MARINE AND ESTUARINE INVERTEBRATES

Species	Test Duration	Concentration (mg/liter)	Results	Reference
Mollusca				
Crassostrea gigas				
Embryos	42-48 hr	0.5	100% survival	Calabrese et al., 1973
		2.45	50% mortality	
Mytilus edulis	130 days	0.0	50% mortality, 218 days	Schulz-Baldes, 1972
		0.5	50% mortality, 150 days	
		1.0	50% mortality, 129 days	
		5.0	50% mortality, 105 days	
Polychaeta				
Polychaetes (2 spp.)	96 hr	1.85->10	50% mortality	Reish, 1974
Polychaetes (1 sp.)	28 days	1.45	50% mortality	Reish, 1974
Arthropoda				
Artemia salina	Various	1.0	50% mortality	Brown and Ahsanullah, 1971
		5.0-10.0	Growth inhibition	

Table 62

TOXICITY OF ZINC TO MARINE AND ESTUARINE INVERTEBRATES

Species	Test Duration	Concentration (mg/liter)	Results	Reference
Mollusca				
Crassostrea gigas				
Embryos	42-48 hr	0.075	100% survival	Calabrese et al., 1973
	42-48 hr	0.31	50% mortality	
	42-48 hr	0.5	100% mortality	
	--	0.32-1.0	No effect	Okubo and Okubo, 1962
	--	3.2	Development inhibited	
Larvae	5 days	0.125-0.5	Reduced growth, increased abnormalities	Brereton et al., 1973
	5 days	0.05	Little effect on development	
	5 days	0.2	Growth inhibited	
Crassostrea virginica	20 wks	100-200	7% mortality, similar to controls	Shuster and Pringle, 1969
Ostrea edulis (larvae)	96 hr	0.1-0.5	Growth inhibited	Walne, 1970
	96 hr	2.5-5.0	No growth	
Mytilus edulis				
Embryos	--	0.32	No effect	Okubo and Okubo, 1962
	--	1.0	Development inhibited	
Adults	--	500	No effect on oxygen uptake	Brown and Newell, 1972
Polychaeta				
Polychaetes (5 spp.)	96 hr	0.9->15	50% mortality	Reish, 1974
	28 days	0.9-8.6	50% mortality	
Nereis diversicolor	816 hr	10-250	24-816 hr mean survival time (from low-Zn area)*	Bryan and Hummerstone, 1973
	816 hr	10-250	30-816 hr mean survival time (from high-Zn area)*	
	408 hr	5-25	52-349 hr mean survival time (from low-Zn area)†	
	408 hr	5-25	70-394 hr mean survival time (from high-Zn area)†	

*Salinity 17.5‰.
†Salinity 3.5‰.

Table 62 (Concluded)

Species	Test Duration	Concentration (mg/liter)	Results	Reference
Ectoprocta				
Bugula neritina (larvae)	--	5.2	50% mortality, 2 hr	Wisely and Blick, 1967
Bugula sp.	48 hr	1.0	Survived, 22.5 hr	Riley, in Ketchum, 1952
	5 hr	5.0	100% mortality	
Arthropoda				
Artemia salina				
Adult	Various	1.0	50% mortality, 312 hr	Brown and Ahsanullah, 1971
	Various	1.0-10.0	Growth inhibition	
	24 hr	160-275	50% mortality	Okubo and Okubo, 1962
Larvae	Various	1.0	50% mortality, 150 hr	Brown and Ahsanullah, 1971
Crangon crangon	48 hr	120	50% mortality	Portmann, 1968
Balanus amphitrite	--	32	No effect	Okubo and Okubo, 1962

Table 63

TOXICITY OF MERCURY TO MARINE AND ESTUARINE INVERTEBRATES

Species	Test Duration	Concentration (mg/liter)	Results	Reference
Mollusca				
Crassostrea gigas				
Embryos	42-48 hr	0.001	100% survival	Calabrese et al., 1973
	42-48 hr	0.0056	50% mortality	
	42-48 hr	0.008	100% mortality	
Crassostrea virginica	92 days	0.01	5% mortality, similar to controls	Cunningham and Tripp, 1973
	92 days	0.10	65% mortality	
Crassostrea commercialis				
Larvae	--	181	50% mortality, 2 hr	Wisely and Blick, 1967
Ostrea edulis				
Larvae	--	0.0033	50% mortality, 4.2 hr	Connor, 1972
	--	0.001-0.0033	50% mortality, 48 hr	
Mytilus edulis planulatus				
Larvae	--	13.0	50% mortality, 2 hr	Wisely and Blick, 1967
Mytilus edulis				
Embryos	--	0.032	Development inhibited	Okubo and Okubo, 1962
	--	0.01	No effect	
Venus japonica	--	0.3	Survived 6-10 days	Irukayama, in Keckes and Miettinen, 1972
Polychaeta				
Polychaetes (4 spp.)	96 hr	0.027-0.7	50% mortality	Reish, 1974
Polychaetes (3 spp.)	28 days	0.09-0.22	50% mortality	Reish, 1974
Ectoprocta				
Bugula neritina (larvae)	--	0.2	50% mortality, 2 hr	Wisely and Blick, 1967
Bugula sp.	48 hr	1.0	100% mortality, 2 hr	Riley, in Ketchum, 1952
	5 hr	0.5	100% mortality	

Table 63 (Concluded)

Species	Test Duration	Concentration (mg/liter)	Results	Reference
Arthropoda				
Artemia salina				
Larvae	57 hr	30-100	50% mortality, 11-57 hr	Corner and Sparrow, 1956
	57 hr	100-750	50% mortality, 3-11 hr	
Adult	24 hr	21-50	50% mortality	Okubo and Okubo, 1962
	Various	1.0	50% mortality, 25 hr	Brown and Ahsanullah, 1971
Crangon crangon				
Adult	48 hr	6	50% mortality	Portmann, 1968
Larvae	--	0.033	50% mortality, 20 hr	Connor, 1972
	--	0.33	50% mortality, 5.1 hr	
	--	3.3	50% mortality, 1.5 hr	
Balanus amphitrite	--	0.32	No effect	Okubo and Okubo, 1962
Balanus balanoides				
Nauplii	6 hr	0.23	50% mortality	Pyefinch and Mott, 1948
Cyprids	6 hr	3.0	50% mortality	
Setting cyprids	days	0.01	Setting inhibited	
Setting cyprids	days	0.05	Setting prevented	
Adults	hr	0.36	50% mortality	
Balanus crenatus				
Nauplii	6 hr	0.09	50% mortality	Pyefinch and Mott, 1948
Cyprids	6 hr	1.0	>50% mortality	
Metamorphosing cyprids	24 hr	0.5-10.0	Metamorphosis inhibited	
Juveniles	--	0.5-10.0	Lethal	
Adults	24 hr	1.35	50% mortality	
Balanus balanoides	--	1.0	Lethal, 2 days	Clarke, 1947
	--	0.5	Lethal, 5 days	
Balanus improvisus				
Cyprids	--	3.3	No effect on metamorphosis	Clarke, 1947

Also having an influence are the species, size or age, nutritional state, and environmental history of the animal. Bryan (1971) reviewed the influence of a number of these factors on heavy-metal toxicity.

In general, larval forms are less tolerant of the presence of heavy metals than adult forms, large animals tend to be more tolerant than small ones, and starved animals tend to be less tolerant than well-fed ones. The toxicity of heavy metals generally increases with increasing temperature and with decreasing salinity of the water. Several investigators (Corner and Sparrow, 1956; Pyefinch and Mott, 1948; Barnes and Stanbury, 1948; Ketchum, 1952) have reported a synergistic relationship between mercury and copper.

Some benthic organisms can build a resistance to the toxic effects of heavy metals. Laboratory tests performed by Bryan and Hummerstone (1971) on Nereis diversicolor showed that animals collected from areas of high copper pollution were much more resistant to the toxic action of copper sulfate than animals collected from areas with less copper. Mean toxic tissue levels were 220 µg/g for animals from the low-copper area, 320 µg/g for animals from the medium-copper area, and 720 µg/g for animals from the high-upper area.

These investigators found evidence that resistance to the toxic effects of copper may be due to genetic changes rather than to short-term physiological adaptation. Bryan and Hammerstone took N. diversicolor from areas of high copper pollution and placed them in sediment with low copper content. Concurrently, they performed the reverse procedure and found that animals with a low copper history did not acquire tolerance to high copper levels after 45 days of exposure and that animals with a high copper history did not lose their tolerance after 76 days of exposure. The investigators reasoned that time had been sufficient for genetic selection to occur because the highly polluted estuaries had been receiving copper-mine wastes for over 200 years.

Although the adverse effects of heavy metals generally are emphasized, certain metals are essential for life. As yet, the physiological and biochemical necessity of cadmium, lead, and

mercury has not been established for marine and estuarine invertebrates, but zinc and copper appear to be essential for the proper functioning of certain enzyme systems in certain animals.

Zinc is an essential constituent of many enzymes, including carbonic anhydrase, alkaline phosphatase, carboxypeptidase, and alcohol dehydrogenase (Williams, 1953). Wolfe (1970a) reported the presence of carbonic anhydrase, alkaline phosphatase, and malic dehydrogenase in oyster tissues. He also discovered that all the zinc in oyster tissues is bound, either to soluble high-molecular-weight proteins or to structural components of the cell. However, in dialysis experiments, Wolfe found that up to 96% of the zinc bound to alkaline phosphatase could be removed without affecting the activity of the enzyme. He concluded that most of the zinc found in oysters serves no useful function. Pequegnat and associates (1969) reached a similar conclusion. These researchers calculated that 2.7 mg/kg of tissue is the maximum essential concentration of zinc in tissues of marine organisms.

The cupric form of copper is considered one of the best catalysts for oxidation-reduction processes (Williams, 1971). It is associated with several enzymes such as lactase, the phenol and polyphenol oxidases, and ascorbic acid oxidase (Lehninger, 1950). Prytherch (1931, 1934) found that traces of copper are essential for the initiation of setting and metamorphosis of oyster larvae. Prytherch observed in laboratory experiments that copper was the only factor that would induce setting of oysters and reported observing larvae setting in maximum numbers in the field when copper concentrations in the water ranged from 0.05 to 0.6 mg/liter. He also found that setting coincided with low tide and maximum river outflow. Mixing of fresh and saline water usually results in the formation of copper colloids, and Prytherch concluded that this was the form of copper that probably was taken up by oyster larvae.

Copper also has been found to be essential in the setting of barnacles, the formation of melanin in the ink of the octopus, the hardening of the exoskeleton and egg encasements of marine invertebrates, and the blackening of blood in some invertebrates after injury (Corcoran and Alexander, 1964).

Uptake and Accumulation of Heavy Metals

Heavy metals may affect aquatic organisms adversely by interfering with some vital process on their external surfaces. Particularly prone to damage are the gills and other soft membranes through which respiration and/or excretion occur.

Metals that are taken up also may have adverse effects on aquatic organisms by inhibiting internal metabolic processes. Uptake may occur via ingestion of sediment, water, or other organisms or by diffusion through semipermeable membranes. Benthic organisms also may acquire metals by ingesting suspended particles to which metals have been adsorbed (Brooks and Rumsby, 1965). Membrane absorption may occur either by simple diffusion or active transport, simple diffusion having been shown to occur in algae and protozoa as well as in multicellular organisms that possess external semipermeable membranes (Pringle et al., 1968). Many benthic forms do not appear to be able to regulate the ionic concentration of their internal fluids, becoming isotonic with their environments. In some animals, uptake of heavy metals across semipermeable membranes may occur to some extent by active transport. According to the carrier hypothesis, certain ions may be transported across membranes as chelates with metabolically produced organic molecules at the expense of energy (Pringle et al., 1968).

A number of field studies have been performed to determine the concentration of a variety of heavy metals in whole benthic animals. Table 64 summarizes data pertaining to whole-body levels of copper, cadmium, lead, zinc, and mercury. Many of the studies reviewed lacked information on the concentration of the metal in question in the sediment or water from which the animals were collected for analysis.

Benthic organisms tend to accumulate certain heavy metals more than others. Of the five metals studied in this investigation, zinc and copper were observed to be accumulated to a greater degree than the other metals.

We found only one study in which heavy metal uptake and accumulation was investigated using animals from San Francisco Bay. This

Table 64

CONCENTRATION OF SELECTED HEAVY METALS IN MARINE AND ESTUARINE INVERTEBRATES

Species	Body Burden (µg/g wet weight)					Environmental Level		Location	Reference
	Copper	Cadmium	Lead	Mercury	Zinc	Water (µg/liter)	Sediment (µg/g)		
Mollusca									
Crassostrea virginica	--	--	--	--	2040	--	--	Unknown	Alexander and Rowland, 1966
	--	--	--	--	85-245	0.55-0.75	--	N. Carolina	Wolfe, 1970b
	--	--	--	--	313-3174	0.8-24	--	Atlantic, Gulf Coasts	Chipman et al., 1958
	--	--	--	--	1500-2800	--	--	Connecticut	Fitzgerald et al., 1962
	48-261*	--	--	--	1200-5700*	--	--	Georgia	Windom and Smith, 1972
	400-3000*	--	--	--	3500-13,500*	--	--	Long Island Sound	Galtsoff, 1964
	92	3	0.5	--	1428	--	--	Atlantic Coast	Pringle et al., 1968
	0-200	0.6 ->2.5	--	--	0->6000	--	100-1500 (Zn)	Chesapeake Bay	Huggett et al., 1973
	--	--	--	0.20†	--	--	--	Delaware Bay	Delaware River Basin Commission, 1970
	--	--	--	0.28	--	--	--	Delaware Bay	Cunningham and Tripp, 1973
	--	--	--	--	0.06	0.005	0.001	N. Carolina	U.S. Dept. Interior, 1966
	72-85	--	--	--	--	--	--	N. Atlantic Coast	Coulson et al., 1932
	16-17	--	--	--	--	--	--	S. Atlantic Coast	Coulson et al., 1932
	16-27	--	--	--	--	--	--	Gulf Coast	Coulson et al., 1932
	9-520†	--	--	--	310-4000†	--	--	Atlantic Coast	McFarren et al., 1962
Crassostrea gigas	13-26	0.8-1.4	<0.2	--	199-275	--	--	Washington	Shuster and Pringle, 1968
	9-192	0-35	--	--	333-10,019	--	--	Tasmania	Ratkowsky et al., 1974
Crassostrea cucullata	--	--	--	--	255	--	28	Bombay, India	Sastry and Bhatt, 1965
Crassostrea madresensis	--	--	--	--	203	--	28	Bombay, India	Sastry and Bhatt, 1965
Crassostrea commercialis	19	0	--	--	318	--	--	Tasmania	Ratkowsky et al., 1974

Table 64 (Continued)

Species	Body Burden (µg/g wet weight) Copper	Cadmium	Lead	Mercury	Zinc	Environmental Level Water (µg/liter)	Sediment (µg/g)	Location	Reference
Mollusca (continued)									
Ostrea sinuta	--	23*	1*	--	172*	--	--	Unknown	Brooks and Rumsby, 1967
	41*	35*	10*	--	1103*	--	Cu 102 Cd <20 Pb <5 Zn <100	New Zealand	Brooks and Rumsby, 1965
Ostrea edulis	1060-1491	--	--	--	717-27,808	--	--	N. Wales	Coombs, 1972
Ostrea angasi	4-81	0.2-19	--	--	371-8865	--	--	Tasmania	Ratkowsky et al., 1974
Ostrea† gigas	13-268	--	--	--	109-953	Cu 0.9-2.9 Zn 17-49	--	Japan	Ikuta, 1968
Mytilus edulis	9	<10	12	--	91	--	Cu 102 Cd <20 Pb <5 Zn 100	New Zealand	Brooks and Rumsby, 1965
	--	--	--	--	81	--	--	New Zealand	Macchi, 1965
	--	--	--	--	253-779*	40-88	--	Wales	Ireland, 1973
	--	--	--	1.0*	40*	--	--	Niewport, Belgium	Bertine and Goldberg, 1972
	--	--	10-20*	--	--	--	--	England	Chapman and Linden, 1927
	--	--	5-6*	--	--	--	--	Ilse Glenan, France	Cheftel et al., 1949
	--	--	0.15-0.36*	--	--	--	--	Vigo, Spain	Costa and Molina, 1957
	--	--	1-30*	--	--	--	--	Bristol, England	Nickless et al., 1972
	--	--	1.9-6.4*	--	--	--	--	Weser Estuary and German Bight	Schulz-Baldes, 1973
	2-4	--	--	--	--	1.0	--	S. California	Marks, 1938
	12-24*	--	--	--	--	1.0	--	S. California	Marks, 1938
	10*	5*	9*	--	91*	--	--	Irish Sea	Segar et al., 1971
	--	31*	--	--	--	0.113	--	Irish Sea	Mullin and Riley, 1956
	--	--	8.4*	--	--	--	--	Germany	Schulz-Baldes, 1972
	5-11*	3-7*	<2-8*	--	204-341*	--	--	N. California (incl. S.F. Bay)	Graham, 1972

Table 64 (Continued)

Species	Body Burden (µg/g wet weight) Copper	Cadmium	Lead	Mercury	Zinc	Environmental Level Water (µg/liter)	Sediment (µg/g)	Location	Reference
Mollusca (continued)									
Mytilus californianus	9-30*	2-5*	<2-23*	--	164-310*	--	--	N. California (incl. S.F. Bay)	Graham, 1972
	1-3	--	--	--	--	1.0	--	S. California	Marks, 1938
Mytilus viridis	--	--	--	--	11	28	--	Bombay, India	Sastry and Bhatt, 1965
Tapes philippinarum	--	--	--	--	19	--	--	Japan	Ichikawa and Ohno, 1974
Tapes semidecussata	19*	10*	<2*	--	11*	--	--	San Francisco Bay	Graham, 1972
Protothaca staminea	8*	6*	5*	--	68*	--	--	San Francisco Bay	Graham, 1972
Paphia staminea	2	--	--	--	--	1.0	--	S. California	Marks, 1938
Modiolus modiolus	27*	6*	33*	--	425*	--	--	Irish Sea	Segar et al., 1971
Busycon canaliculatum	76	--	--	--	--	--	--	Narragansett Bay	Betzer and Pilson, 1974
Crepidula fornicata	270*	4*	41*	--	940*	--	--	Irish Sea	Segar et al., 1971
Mya arenaria	5.8	0.27	0.70	--	17	--	--	Atlantic Coast	Shuster and Pringle, 1968
Polychaeta									
Armandia sp.	3-80	--	--	--	48-250	--	--	Puerto Rico	Phelps et al., 1969
Armandia maculata	--	--	--	--	0	--	--	Puerto Rico	Phelps, 1967
Capitella sp.	--	--	--	--	0	--	--	Puerto Rico	Phelps, 1967
Mageiona sp.	--	--	--	--	0	--	--	Puerto Rico	Phelps, 1967
Nephtys incisa	--	--	--	--	99*	--	--	Massachusetts	Phelps, 1967
	--	--	--	--	42*	--	--	Rhode Island	Phelps, 1967
Prionospio sp.	--	--	--	--	0	--	--	Massachusetts	Phelps, 1967
Nereis sp.	--	--	--	--	25*	--	--	Massachusetts	Phelps, 1967
Pectinaria sp.	--	--	--	--	0	--	--	Rhode Island	Phelps, 1967

Table 64 (Concluded)

Species	Body Burden (μg/g wet weight) Copper	Cadmium	Lead	Mercury	Zinc	Environmental Level Water (μg/liter)	Sediment (μg/g)	Location	Reference
Polychaeta (continued)									
Nereis diversicolor	22-1142*	--	1-6*	--	155-199*	--	Cu 41-3020* Pb 21-359* Zn 99-2237*	S.W. England	Bryan and Hummerstone, 1971
	662-2573*	--	--	--	--	3-5530	3199-3985*	Restronguet Creek, England	Bryan and Hummerstone, 1971
	56-167*	--	--	--	--	1-6	210-407*	Tamar, England	Bryan and Hummerstone, 1971
	21*	--	--	--	--	<1	38*	Dart, England	Bryan and Hummerstone, 1971
	--	0.08-3.6*	--	--	130-250*	Zn 10-1140	Cd 0.2-9.3* Zn 97-2980*	S.W. England	Bryan and Hummerstone, 1973
Nereis sp.	--	--	--	--	75-95*	--	--	N. Carolina	Cross et al., 1970
Glycera americana	--	--	--	--	140-195*	--	--	N. Carolina	Cross et al., 1970
Arthropoda									
Crangon crangon	--	--	--	1.3+	39*	--	Zn 0.01 Hg 0.00003	Nieuport, Belgium	Bertine and Goldberg, 1972
Crangon allmani	56-112+	1.2-3.5*	16-23+	--	121-166*	--	--	Firth of Clyde	Halcrow et al., 1973
Balanus amphitrite communis	--	--	--	--	72	28	--	Bombay, India	Sastry and Bhatt, 1965
Balanus eburneus	--	--	--	--	3.6	6.8	10-18	Texas	Parker, 1962
Balanus balanoides	--	--	--	--	4500-23,100*	40-88	--	Wales	Ireland, 1973
	--	0.1*	--	--	--	0.113	--	Irish Sea	Mullin and Riley, 1956
	29	--	--	--	--	--	--	Unknown	Culkin and Riley, 1958
Cancer pagurus	35	--	--	--	--	--	--	Unknown	Culkin and Riley, 1958
	--	0.1*	--	--	--	0.113	--	Irish Sea	Mullin and Riley, 1956
Cancer magister	--	--	--	--	566	--	--	Unknown	Carey, in Pequegnat et al., 1969

*Dry weight.

+Wet or dry weight not specified.

study was conducted by Anderlini and coworkers (1974) in Mare Island Strait. The concentrations of heavy metals in the sediment, water, and animals at several stations were monitored over six-months, which included two periods of major dredging activity by the Corps of Engineers. These investigators found no relationship among the levels of copper, cadmium, lead, zinc, or mercury in the sediment, water, or animals and the station or time, except for a slight decrease in lead concentrations with time. The effect of dredging on heavy-metal concentrations was difficult to evaluate because the two periods of heavy dredging activity coincided with the two heaviest rainfalls of the study period.

Ninety-five percent or more of the lead in the water column was associated with suspended particles. The concentrations of the metals associated with suspended particles were similar to those observed in the bottom sediments. Concentrations of copper, lead, and mercury were higher in the sediment than in the invertebrates, whereas the reverse was true for cadmium and zinc. Cadmium concentrations were six times higher in Ischadium demissum and Mytilus edulis than in sediments. Zinc concentrations were up to 2.8 times higher in Neanthes succinea, Macoma balthica, and native and transplanted Mytilus edulis than in sediments. The fluctuations in levels of metals in the invertebrates did not correlate with fluctuations of metals in the sediments or with copper or lead in suspended particles.

The accumulation from water of mercury, lead, and copper by Macoma balthica was studied in a nine-day laboratory experiment. One to three concentrations (2.5, 5, and 10 μg/liter above ambient) and three salinities (5, 12.5, and 25‰) were used.

The amount accumulated increased with time and with increasing concentration and decreasing salinity. Anderlini and his associates (1974) suggested that, if this were true for other invertebrates and metals, the low salinity recorded during the second dredging period could have been the cause of the few gradual increases in concentrations of metals in the animals at that time.

Mytilus edulis from Mare Island Strait had up to four times the metal content of M. edulis from Tomales Bay. When M. edulis

was transplanted to Mare Island Strait, metal concentrations increased, but _M. edulis_ transferred from Mare Island Strait to Tomales Bay had metal levels lower than the baseline sample by a factor of two to three in 27 days.

The magnitude of heavy-metal accumulation appears to be governed by several factors, one being the manner by which an organism feeds. According to Phelps and his coworkers (1969), nonselective deposit feeders tend to accumulate more zinc than selective deposit feeders, and filter feeders tend to accumulate the least. Phelps (1967) also found that metal partitioning occurred between nonselective and selective feeders, iron being taken up preferentially by selective feeders and zinc being accumulated preferentially by nonselective feeders. Phelps attributed this difference to where and on what these two types of animals feed. Since selective types feed mostly at the sediment-water interface and mostly on freshly settled particulate matter, Phelps (1967) reasoned that they are most apt to ingest particulate or colloidal iron; nonselective types as well as omnivores and carnivores feed primarily on surface and subsurface sediment and/or other organisms. He hypothesized that zinc would be more available to subsurface feeders because of the tendency of zinc to be released from the sediment under anaerobic conditions.

That zinc or other metals are released more readily from sediment under anaerobic conditions is not accepted by all investigators. Bachmann (1963) and Phelps (1967) have agreed this is true; but Bryan and Hummerstone (1971) and Anderline and coworkers (1974) presented evidence that heavy-metal desorption occurs most readily under aerobic conditions.

Although Phelps (1967) reported finding selective accumulation of zinc and iron by animals having different feeding mechanisms, Cross and coworkers (1970) could not substantiate this phenomenon. In their investigation of the accumulation of metals by polychaetes, they found that _Nereis_ sp., which they classified as a subsurface feeder, accumulated zinc and iron to the same degree as surface feeding polychaetes. Evidence exists, however, that _Nereis_ sp. does not feed exclusively on subsurface particles but also can feed by filtration and will feed on surface particles (Harley, 1953;

Goerke, 1971); if this polychaete does, in fact, feed by several mechanisms, it is not likely that evidence that selective metal accumulation would appear.

Several investigators have reported that some benthic organisms tend to regulate the amount of metal retained. Bryan and Hummerstone (1971), who have performed relatively comprehensive studies on the relationship of environmental heavy metal levels and the toxicity and accumulation of metals by Nereis diversicolor, compared the amount of copper, zinc, lead, manganese, and iron in this polychaete with that in the sediment. Their study was conducted in seven estuaries in southwest England. Although the average concentration of copper in the sediment ranged from 20 to more than 9,000 μg/g dry weight, depending on the estuary, the animal-to-sediment ratio for copper ranged from 0.24 to 0.68. Sediment concentrations for zinc ranged from 99 to 2,237 μg/g dry weight; however, the concentration of the metal in N. diversicolor, which inhabited the sediment, ranged from 155 to 199 μg/g dry weight. Bryan and Hummerstone suggested that either these metals were not available to the animals or the animals were capable of regulating the degree to which the metals accumulated internally.

Bryan and Hummerstone (1973) reported strong evidence that zinc is regulated by N. diversicolor but no evidence that cadmium is. They found that the concentration of zinc in the sediment varied by a factor of 30, but the concentration of zinc in specimens of N. diversicolor removed from the same sediment varied by a factor of only 2.7. On the other hand, the sediment and whole body concentrations of cadmium varied by about the same factor.

Cross and coworkers (1970) reported that, at two stations where the median sediment metal content differed by a factor of 4 for manganese, 10 for iron, and 8 for zinc, no differences were observed in the whole-body metal content of three of the six polychaete species analyzed. These investigators concluded that either the three species were able to regulate internal metal levels or much of the metal associated with the sediment was unavailable to them. Cross et al. also reported that the levels of the respective metals found in the animals supported another theory on metal accumulation by aquatic organisms: The accumulation or enrichment

of divalent metal ions follows the order of stability of metal ligand complexes (Goldberg, 1957).

Bryan and Hummerstone (1971) suggested possible sites of regulatory activity for N. diversicolor. Analysis of the distribution of copper in various body parts of this worm showed that the parapodia, body wall, and parts of the nephridia associated with the body wall contained the highest amount of copper. Raymont and Shields (1964) reported a similar phenomenon for Nereis virens. However, the parapodia and body wall might be major sites of entry for copper rather than regulatory sites.

Unpublished work cited by Bryan and Hummerstone (1971) showed that the toxicity of copper increases with decreasing salinity. This suggested to them that salinity may influence copper uptake and retention in benthic organisms. Their own work on the relationship between copper uptake and salinity was inconclusive, but Cronin and associates (1974) found that the rate of uptake of zinc and copper by hatchery-reared oysters (C. virginica) increased with decreasing salinity and that oysters placed in areas of low salinity had much higher levels of cadmium than those transferred from the hatchery to areas of high salinity.

Heavy-Metal Availability

Many investigators have demonstrated that heavy metals can be highly toxic to benthic animals in the ionic form; yet, as we and others have discovered, benthic organisms can occur in relatively great abundance in areas where the sediment contains very high levels of heavy metals. The apparent tolerance is not limited to a few species. At Oakland Inner Harbor, where the sediment was more highly contaminated with heavy metals than at any other area we investigated, we found a great diversity of benthic macrofauna. This apparent paradox can be explained to a large extent by availability.

Metals can exist in seawater in at least four different forms: (1) as part of living organisms, (2) as colloidal particles, (3) adsorbed to other colloidal particles, and (4) in true solution (Leland et al., 1974). Trace metals in true solution generally form

complexes with a number of other ions normally found in seawater. These complexes include $CuCl^+$, $Cu(OH)^+$, $CdCl^+$, $CdCl_2$, $Cd(OH)^+$, $PbCl^+$, $HgCl_4{}^{2-}$, and $ZnCl^+$ (Krauskopf, 1956). Several factors may affect the conversion of these forms. Zirino and Yamamoto (1972) discussed the pH-dependent reactions of copper zinc, cadmium, and lead with the anions, OH^-, Cl^-, $SO_4{}^{2-}$, HCO_3^-, and $CO_3{}^{-2}$ in seawater between pH 7 and 9. They formulated a model based on available and estimated individual ion activity coefficients and stability constants, assuming the metals were in the divalent state, and developed a different set of ionic species than that formulated by Krauskopf. Their results showed that, at different pH values, the dominant ionic species were different.

In the pH range studies by Zirino and Yamamoto, all four metals occurred primarily as complexes, with only a few species predominating for each metal. Copper was associated primarily with hydroxide and carbonate ions. The dominant species were $CuCO_3$ and Cu^{2+} at pH 7.0 and $Cu(OH)_2^0$ at pH 7.5 and 8.1. Cadmium complexed strongly only with chloride ions throughout the entire pH range studied. The dominant species was $CdCl_2^0$, followed in decreasing order by $CdCl^+$, $CdCl_3^-$, and Cd^{2+}. Lead reacted mainly with carbonate and to a lesser extent with chloride ions. $PbCl^+$ dominated at pH 7.0, and $PbCO_3^0$ dominated at pH 7.5 and 8.1. Zinc did not complex as readily as did the other metal ions at pH 7.0 and 7.5, but it complexed strongly with the hydroxide ion at pH 8.0. Zinc complexes were formed with sulfate, but the amount was insignificant. Goldberg and Arrhenius (1958) determined, however, that approximately 10% of the amount of zinc in seawater is present as sulfates.

Several investigators have found organic complexes of metals in sea water. Rona and coworkers (1962) and Slowey and Hood (1966) reported that zinc and copper in seawater were not dialyzable, suggesting the existence of a complexed form they believed to be organic. Corcoran and Alexander (1964) found that copper in seawater from Florida existed primarily in the soluble, nonionic state, probably as an organic molecule. Little of this metal was found in the particulate or ionic form. Williams (1969) also presented evidence supporting the presence of organically bound copper in seawater.

Complexed copper, as well as copper associated with suspended solids, has been found analytically in fresh water (Stiff, 1971). Morel et al. (1973) reviewed the speciation of metallic ions in fresh water and the roles of acid-base components, oxidation-reduction status, solubility, and complexation. Lerman and Childs (1973) discussed complexation of metals in fresh water by the organic compounds nitrilotriacetate (NTA) and citrate, which may appear in waters affected by industrial societies.

The concentration of heavy metals in solution in the ocean is orders of magnitude less than that calculated to have accumulated in the ocean from weathering of land during geologic time (Krauskopf, 1956). Sonnen (1965) reported that a number of investigators have found that zinc in freshwater streams rapidly associates with suspended sediment. The settling of sediment particles effectively removes metals from solution. Many other studies (Duursma and Gross, 1971; Cross et al., 1970; Duke et al., 1966; Pomeroy et al., 1966, Jennings and Osterberg, 1969) have shown that many of the trace metals present in estuarine systems are associated with sediments.

Heavy metals may be removed from solution by several possible mechanisms--precipitation, adsorption to sediment particles or to particulates in the water, and absorption by marine organisms. Krauskopf (1956) calculated that an increase of one pH unit would reduce the solubility of simple, divalent metal carbonates by a factor of 10 and that of divalent metal hydroxides by a factor of 100. By surveying tabulated solubilities, he concluded that the solubility of only a very few unusual metal salts would change by a factor of 100 for a temperature change of 100°C. Neither of these factors nor changes in pressure would alter equilibria sufficiently to account for the observed concentrations of metals in sediment and water. Krauskopf also found that the measured equilibrium concentrations of metals in aerated seawater were of the same order of magnitude as the calculated concentrations, although they exceeded the observed seawater levels considerably.

In local areas of abundant organic matter, anaerobic conditions under which sulfides are produced often prevail. Most metal sulfides are highly insoluble compounds. In addition, strong

reducing agents can change the valence state of metals, resulting in other precipitation reactions. Calculations and experimental determinations of the solubilities of sulfide precipitates in seawater were made under conditions approximating those of a very stagnant Norwegian fjord (pH about 7 and hydrogen sulfide about 0.005 M). Under these conditions, Krauskopf (1956) found that zinc decreased to a concentration comparable to that in nature, but copper, lead, and mercury became undetectable. He suggested that, if cadmium were present, it also would have become undetectable. Krauskopf did not conclude, however, that the formation of insoluble sulfides was a major factor controlling the amount of metals in water because the concentration of the metals studied was not related to the solubilities of their sulfides. Presley and coworkers (1972) found that waters abundant in dissolve sulfides often were laden also with dissolved metal ions, thus supporting Krauskopf's hypothesis.

In studies on metal adsorbents, Krauskopf (1956) found that excess copper, lead, and zinc strongly adsorbed to all adsorbents tested, except plankton, within a few hours, thereby reducing the concentration of these metals to levels normally found in seawater. Mercury showed a strong affinity to clay and organic matter; however, it reached equilibrium slowly. He concluded that adsorption processes are probably the most important controls of metal concentrations.

In a study of the adsorption of mercury (II), MacNaughton (1973) concluded that adsorption was often a major process controlling mercury concentrations in fresh and salt water. The mechanism of zinc adsorption depends primarily on the size of suspended particles. Sand and silt particles generally adsorb zinc physically; clay particles have a large capacity for cation exchange, although some secondary adsorption also may occur on clay surfaces (Robinson, 1962). According to Andelman (1973), the sorption of trace elements onto surfaces can occur without ion exchange as a result of coulombic interactions with the surface in its electric double layer. Most particles of water are negatively charged, and trace cations can be held at the negatively charged surface of colloidal or particulate mineral or other material.

Horne (1969) considered ion exchange at the sediment-water interface to be the most important mechanism for chemical control. Many other investigators (Cross et al., 1970; Halcrow et al., 1973; Smith et al., 1973; McCulloch et al., 1971; Peterson et al., 1972) found greater levels of metals associated with finer-grained sediments than with coarser sediments, which suggests a mechanism of ion exchange. However, Turekian and Scott (1967) found no significant differences in the trace elements associated with sediments of different size fractions. In a review, Battelle Laboratories (1974) cite several studies in which ion exchange appeared insignificant. However, the Battelle report suggested that, although ion exchange might be responsible for binding only a small fraction of the total amount of metal present, the amount may be important because of its relative ease of removal.

Factors that have been shown to affect the extent of heavy-metal adsorption are pH, salinity, temperature, pressure, sediment type, the presence or absence of organic compounds, time, and the concentration of metal cations relative to the concentration of nonmetallic anions.

Preliminary studies by the Battelle Laboratories (1974) indicated that only a small fraction of copper and cadmium are desorbed from sediments, and lead and mercury do not undergo desorption. Copper desorption was greatest at high Eh, high temperature, and low salinity. Cadmium desorption was greatest at high Eh, high temperature, and (unlike copper) at high salinity. The Battelle study suggested that the factors of greatest probable effect on adsorption and desorption of heavy metals are salinity, Eh, time, sediment-to-solution ratio, and sediment metal content. Factors of least importance would include water and sediment pH, bottom water and sediment temperature, and initial heavy metal concentrations in solution. Battelle currently is conducting studies on the effects of the five important factors on sorption and desorption of heavy metals.

MacNaughton (1973) considered the factors most affecting mercury adsorption to be pH, chloride concentration, organic content of the solid adsorbent, and--to a lesser extent--the solid substrate and contact time. Robinson (in Sonnen, 1965) calculated

that exchange capacity would vary logarithmically with hydrogen ion concentration, the concentration of the cation to be exchanged, and the valence of the cation. Robinson's results indicated that, between pH 5.0 and 8.0, increased acidity would cause a corresponding decrease in exchange capacity. Backmann (1963) predicted that a decrease in pH would result in a decrease in adsorption of zinc by ion exchange. Below pH 2.5, mercury (II) is weakly adsorbed, but adsorption abruptly increases above this pH and reaches a maximum at pH 4 to 6 (MacNaughton, 1973). MacNaughton also found chloride to be the only anion common to natural waters that interferes significantly with the adsorption of mercury (II). Sonnen (1965) conducted laboratory studies that demonstrated that a saline environment favors the desorption of zinc from suspended sediment. He concluded that zinc, adsorbed to sediments washed into the estuary from freshwater areas, would be released into solution if sufficient mixing of fresh and salt water occurred in an estuary. Such releases would become significant when the concentration of salts in the mixture reached 5% of the salinity of pure seawater. Sonnen also concluded that significant amounts of zinc would be released even if the two types of water remained stratified because of differences in density.

Trace metals tend to interact with organic compounds, especially through the mechanisms of complex and chelate formation (Andelman, 1973). MacNaughton (1973) reported that suspended or deposited sediments composed primarily of organic detritus or containing adsorbed organics strongly adsorb mercury. The degree of adsorption was unaffected by chloride, and desorption occurred only when the organic material was destroyed or desorbed. MacNaughton used relatively high amounts of organic materials in his experiments--more than is usually present in fresh or salt water--and he cautioned that his results may have been somewhat exaggerated. Nevertheless, the results do indicate that bound mercury and, probably, other metals might be incorporated into the estuarine sediments if suspended material carried by a river were deposited in an estuary. Duke and Rice (1967) reported that EDTA reduced the availability of radiozinc to an experimental biological community in laboratory experiments. In contrast to the findings of Andelmann, MacNaughton, and Duke and Rice, several studies cited in the Battelle report (1974) indicated that organic binding is an insignificant binding

mechanism. Stumm and Balinski (in Battelle Northwest Laboratories, 1974) found many organic ligands to which heavy metals might bind in natural waters, the functional groups of these ligands showing little specificity toward individual metal ions; in the presence of magnesium and calcium ions, which are much more abundant in natural water than trace metals, the ligands tended to bind with the more abundant divalent ions.

The degree of heavy-metal adsorption to the sediment also has been shown to be related to sediment type. MacNaughton (1973) found that freshly precipitated ferric hydroxide had the strongest affinity for mercury (II), whereas manganese oxide, goethite, and kaolinite displayed slightly weaker bonding. Quartz, alumina, and montmorillonite adsorbed mercury by almost an order of magnitude less than other solids per unit area and with the same equilibrium metal ion concentration.

Robinson (1962) reported that the composition of clay was one of the major factors influencing cation exchange equilibria. The attraction of a cation in solution to the ionic constituents of clay was apparently strongest in those ions in corner positions of the lattice structure, next strongest in the ions on the edges, then in those on the plane surfaces. He stated that the accessibility of these three sites can affect the exchange capacity of a single clay or can be an important factor in accounting for differences in the exchange capacities of different clays.

Certain substances may obstruct or clog the exchange sites. Dion (1944) found that ferric oxide, in both the hydrated and non-hydrated forms, exhibits a clogging effect on clay minerals. Hendricks (1941) proposed that some organic ions adsorbed on the basal surfaces of montmorillonite may obstruct the exchange positions.

Most investigators have found that increasing the concentration of a particular cation in the solution increases its replacing power in relation to the exchange equilibrium (Sonnen, 1965). Krauskopf (1956) reported observing a lower percentage of mercury adsorbed to iron oxide or apatite at higher initial mercury concentrations, and Sonnen found that the release of adsorbed zinc

from suspended sediment was greatest when the initial amount of ionic zinc was highest.

Investigators disagree about the effects of different anions on cation exchange capacity. Nezyaka reported in a personal communication to Grim (1953) that he found a difference in the replaceability of sodium and calcium ions in montmorillonite that depended on whether calcium hydroxide or sulfate was used. Elgabaly and Jenny (1943) suggested, however, that the formation of basic salts with the clay and a soluble anion, such as clay-$Zn(OH)^+$, complicates the question of whether a portion of the effect is the result of a pH shift. Other investigators have found anions to have little, if any, influence on cation exchange.

Not all heavy metals in sediments are exchanged rapidly in water. Some may occupy a position within the crystalline lattice. By using different extraction procedures, several investigators found large amounts of metals in the lattice structure of clay. Chester and Hughes (1969) found that most of the copper (72%) and lead (86%) in sediments analyzed were of lithogenous origin (derived from weathering of land). Hirst (1962) also arrived at similar results. Elgabaly and Jenny (1943) reported that zinc also may occupy spaces in the lattice structure of clays, and Presley and associates (1972) found 61% of the zinc and 43% of the copper in their sediment samples to be of lithogenous origin.

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APPENDIX A

DISTRIBUTION AND ABUNDANCE OF TAXA

CONTENTS

MIS-A
Survey P

STATION MIS-A

PRELIMINARY SURVEY

TAXA	SAMPLE NO. 1	2	3	4	NUMBER OF GROUP	SPECIMENS TAXA
NEMATODA					7	
NEMATODA-UNIDENTIFIED SPP.	6	--	1	--		7
ANNELIDA-OLIGOCHAETA					9	
OLIGOCHAETA-UNIDENTIFIED SPP.	9	--	--	--		9
ARTHROPODA					100	
COPEPODA-UNIDENTIFIED SPP.	92	--	3	--		95
OSTRACODA-UNIDENTIFIED SPP.	--	1	--	--		1
BALANUS CRENATUS	--	1	--	--		1
MYSIDACEA-UNIDENTIFIED SPP.	3	--	--	--		3
MOLLUSCA					16	
MACOMA BALTHICA	2	--	--	9		11
MACOMA SP., CF NASUTA	--	--	1	--		1
MYA ARENARIA	--	--	4	--		4
ECTOPROCTA					P	
CHEILOSTOMATA-UNIDENTIFIED SPP.	P	P	--	--		P
MEMBRANIPORA PERFRACILIS	--	P	P	--		P
GRAND TOTALS 11	112	2	9	9	132	132

MIS-B
Survey P

STATION MIS-B

PRELIMINARY SURVEY

TAXA		SAMPLE NO. 1	2	3	4	NUMBER OF GROUP	SPECIMENS TAXA
NEMATODA						7	
NEMATODA-UNIDENTIFIED SPP.		4	--	--	3		7
ANNELIDA-OLIGOCHAETA						232	
OLIGOCHAETA-UNIDENTIFIED SPP.		51	24	23	134		232
ANNELIDA-POLYCHAETA						5	
STREBLOSPIO BENEDICTI		--	--	1	4		5
ARTHROPODA						19	
COPEPODA-UNIDENTIFIED SPP.		7	1	1	4		13
MYSIDACEA-UNIDENTIFIED SPP.		--	1	--	--		1
AMPELISCA MILLERI		--	--	--	3		3
AMPHIPODA-UNIDENTIFIED SPP.		--	--	--	1		1
INSECTA-UNIDENTIFIED SPP.		1	--	--	--		1
MOLLUSCA						89	
MYA ARENARIA		3	1	1	15		20
MACOMA BALTHICA		3	4	2	54		63
NASSARIUS OBSOLETUS		--	--	2	4		6
ECTOPROCTA						P	
MEMBRANIPORA PERFRAGILIS		--	--	--	P		P
GRAND TOTALS	12	69	31	30	222	352	352

STATION CS-A

PRELIMINARY SURVEY

TAXA	SAMPLE NO. 1	2	3	4	5	NUMBER OF GROUP	SPECIMENS TAXA
CNIDARIA						P	
HYDROZOA-UNIDENTIFIED SPP.	--	P	--	--	--		P
NEMATODA						9	
NEMATODA UNIDENTIFIED SPP.	--	9	--	--	--		9
ANNELIDA-OLIGOCHAETA						53	
OLIGOCHAETA-UNIDENTIFIED SPP.	--	44	--	1	8		53
ANNELIDA-POLYCHAETA						9	
HETEROMASTUS FILIFORMIS	--	1	--	--	--		1
STREBLOSPIO BENEDICTI	--	5	1	--	1		7
ETEONE LIGHTI	--	1	--	--	--		1
ARTHROPODA						2	
MYSIDACEA-UNIDENTIFIED SPP.	--	1	--	--	--		1
SYNIDOTEA LATICAUDA	--	--	--	--	1		1
MOLLUSCA						119	
NASSARIUS OBSOLETUS	6	6	7	3	19		41
MYA ARENARIA	12	21	1	--	5		39
MACOMA BALTHICA	8	12	3	6	7		36
MYTILUS EDULIS - JUVENILE	1	--	--	--	--		1
TAPES JAPONICA	--	2	--	--	--		2
ECTOPROCTA						P	
MEMBRANIPORA PERFRAGILIS	P	P	--	--	--		P
CHEILOSTOMATA-UNIDENTIFIED SP. A	--	--	P	--	--		P
CHEILOSTOMATA-UNIDENTIFIED SP. B	--	--	P	--	--		P
GRAND TOTALS 16	27	102	12	10	41	192	192

CS-B
Survey P

STATION CS-B

PRELIMINARY SURVEY

TAXA	SAMPLE NO. 1	2	3	4	5	NUMBER OF GROUP	SPECIMENS TAXA
PORIFERA						P	
PORIFERA-UNIDENTIFIED SPP.	--	P	--	--	--		P
NEMERTEA						1	
NEMERTEA-UNIDENTIFIED SPP.	1	--	--	--	--		1
NEMATODA						2	
NEMATODA-UNIDENTIFIED SPP.	1	--	--	1	--		2
ANNELIDA-OLIGOCHAETA						2	
OLIGOCHAETA-UNIDENTIFIED SPP.	--	2	--	--	--		2
ANNELIDA-POLYCHAETA						15	
ASYCHIS SP.	5	--	--	--	--		5
STREBLOSPIO BENEDICTI	4	2	--	--	2		8
HETEROMASTUS FILIFORMIS	--	--	--	--	1		1
NEANTHES SUCCINEA - JUVENILE	--	--	--	--	1		1
ARTHROPODA						3	
COPEPODA-UNIDENTIFIED SPP.	2	--	--	--	--		2
CANCRIDAE-UNIDENTIFIED JUVENILE	--	--	--	--	1		1
MOLLUSCA						11	
MYA ARENARIA	1	--	1	--	--		2
MUSCULUS SENHOUSIA	5	1	--	--	--		6
MYTILUS EDULIS	--	3	--	--	--		3
ECTOPROCTA						P	
MEMBRANIPORA PERFRAGILIS	P	P	--	P	P		P
CHEILOSTOMATA-UNIDENTIFIED SPP.	--	P	--	P	--		P
GRAND TOTALS 15	19	8	1	1	5	34	34

ALC
Survey P

STATION ALC

PRELIMINARY SURVEY

TAXA	SAMPLE NO. 1	2	3	NUMBER OF GROUP	SPECIMENS TAXA
ANNELIDA-POLYCHAETA				6	
GLYCERA OXYCEPHALA	1	2	--		3
GLYCINDE SP.	--	--	3		3
MOLLUSCA				3	
MACOMA NASUTA	--	--	3		3
ECTOPROCTA				P	
CHEILOSTOMATA-UNIDENTIFIED SPP.	P	--	--		P
CELLARIA MANDIBULATA	--	P	--		P
SCRUPOCELLARIA SP.	--	--	P		P
TRICELLARIA SP., ? OCCIDENTALIS	--	--	P		P
GRAND TOTALS 7	1	2	6	9	9

OIH
Survey P

STATION OIH

PRELIMINARY SURVEY

TAXA	SAMPLE NO. 1	2	3	4	5	NUMBER OF GROUP	SPECIMENS TAXA
PORIFERA						P	
KERATOSA-UNIDENTIFIED SPP.	--	--	--	P	P		P
CNIDARIA						3	
PENNATULACEA-UNIDENTIFIED SPP.	--	--	--	1	1		2
CF DIADUMENE SP.	--	--	--	--	1		1
CALYPTOBLASTEA-UNIDENTIFIED SPP.	--	--	--	P	--		P
CNIDARIA-UNIDENTIFIED SPP.	--	--	--	--	P		P
NEMERTEA						24	
NEMERTEA-UNIDENTIFIED SPP.	--	2	5	11	6		24
NEMATODA						306	
NEMATODA-UNIDENTIFIED SPP.	73	148	6	23	56		306
ANNELIDA-OLIGOCHAETA						4886	
OLIGOCHAETA-UNIDENTIFIED SPP.	645	806	1370	1376	689		4886
ANNELIDA-POLYCHAETA						13323	
HETEROMASTUS FILIFORMIS	1	--	2	--	--		3
MEDIOMASTUS CALIFORNIENSIS	7	--	4	--	1		12
HAPLOSCOLOPLOS PUGETTENSIS	1	2	14	10	8		35
PECTINARIA CALIFORNIENSIS	7	5	5	8	9		34
POLYDORA LIGNI	1	2	1	--	--		4
PSEUDOPOLYDORA PAUCIBRANCHIATA	8	6	23	24	3		64
SCOLELEPSIS SQUAMATA	1	1	6	5	23		36
STREBLOSPIO BENEDICTI	675	1886	2994	3101	2059		10715
GLYCERA AMERICANA	1	--	--	--	1		2
GLYCINDE SP.	11	6	16	9	8		50
NEPHTYS CAECOIDES	10	3	10	16	14		53
PHOLOE MINUTA	3	2	1	12	5		23
EXOGONE LOUREI	293	325	653	440	260		1971
SPHAEROSYLLIS SP.	33	17	80	42	20		192
PSEUDOPOLYDORA KEMPI CALIFORNICA	--	4	5	17	4		30
NEPHTYS CORNUTA FRANCISCANA	--	1	1	2	26		30

STATION OIH PRELIMINARY SURVEY (CONT.)

TAXA	SAMPLE NO. 1	2	3	4	5	NUMBER OF GROUP	SPECIMENS TAXA
NEPHTYS PARVA	--	1	--	--	--		1
ETEONE LONGA CALIFORNICA	--	5	9	1	1		16
CAPITELLA CAPITATA	--	--	6	6	--		12
THARYX SP.	--	--	2	--	--		2
MYRIOCHELE SP., NEAR GRACILIS	--	--	2	--	--		2
TROCHOCHAETA MULTISETOSUM - JUVENILE	--	--	3	1	1		5
CIRRATULUS CIRRATUS	--	--	--	5	--		5
THARYX SP., CF PARVUS	--	--	--	4	1		5
SCHISTOMERINGOS LONGICORNIS	--	--	--	3	2		5
SCHISTOMERINGOS SP., CF LONGICORNIS	--	--	--	1	--		1
GLYCERA SP., NEAR ROBUSTA	--	--	--	1	--		1
ETEONE DILATAE	--	--	--	1	--		1
HARMOTHOE IMBRICATA	--	--	--	1	--		1
CHAETOZONE SP.	--	--	--	--	1		1
ASYCHIS SP.	--	--	--	--	1		1
HARMOTHOE SP., CF IMBRICATA	--	--	--	1	--		1
NEPHTYS SP., CF CORNUTA FRANCISCANA	--	1	--	--	--		1
PHYLLODOCIDAE-UNIDENTIFIED SPP.	--	--	--	1	--		1
POLYDORA SOCIALIS	--	--	--	3	--		3
MEDIOMASTUS CALIFORNIENSIS - JUVENILE	--	--	--	--	1		1
ETEONE LONGA CALIFORNICA - JUVENILE	--	--	--	--	1		1
GLYCINDE SP. - JUVENILE	--	--	--	--	1		1
NEPHTYS CAECOIDES - JUVENILE	--	--	--	--	1		1
ARTHROPODA						[illegible]	
OSTRACODA-UNIDENTIFIED SPP.	19	9	136	70	--		234
CUMACEA-UNIDENTIFIED SP. A	2	--	3	5	3		13
CUMACEA-UNIDENTIFIED SP. B	2	--	1	5	--		8
AMPELISCA MILLERI	3	6	10	12	1		32
LEPTOCHELIA DUBIA	1	--	7	--	--		[illegible]
CRANGON SP.	--	--	1	--	--		1
AMPHIPODA-UNIDENTIFIED SPP.	--	--	--	1	--		1
PHOTIS CALIFORNICA	--	--	--	1	--		1
PINNIXA FRANCISCANA	--	--	--	1	1		2
LECYTHORHYNCHUS MARGINATUS	--	--	--	2	--		2
CUMACEA-UNIDENTIFIED SPP.	--	--	--	--	3		3
PYROMAIA TUBERCULATA	--	--	--	--	1		1
EUDORELLA PACIFICA	1	--	1	--	--		2
BRACHYURA-UNIDENTIFIED LARVA	--	--	1	--	--		1
MOLLUSCA						[illegible]	
MACOMA ACOLASTA	1	--	--	--	--		1
MACOMA INQUINATA	1	--	--	2	--		[illegible]
MACOMA NASUTA	25	22	28	34	2?		[illegible]

OIH
Survey P

OIH
Survey P

STATION OIH PRELIMINARY SURVEY (CONT.)

TAXA	SAMPLE NO. 1	2	3	4	5	NUMBER OF GROUP	SPECIMENS TAXA
TELLINA MODESTA	1	--	1	--	--		2
TAPES JAPONICA	1	1	--	--	--		2
GEMMA GEMMA	512	322	502	369	310		2075
TRANSENNELLA TANTILLA	2	3	--	5	2		12
MYSELLA FERRUGINOSA	1	2	2	4	2		11
MUSCULUS SENHOUSIA	16	3	17	5	4		45
SILIQUA PATULA	--	--	1	--	--		1
MACOMA BALTHICA - JUVENILE	--	--	--	2	--		2
SILIQUA SLOATI	--	--	--	2	--		2
ADULA DIEGENSIS	--	--	--	1	--		1
MYTILUS EDULIS	--	--	--	--	3		3
PELECYPODA-UNIDENTIFIED SPP.	1	--	--	--	--		1
ODOSTOMIA (EVALEA) SP., CF TENUISCULPTA	--	--	--	1	--		.
ECTOPROCTA						P	
HIPPOTHOA HYALINA	--	--	--	P	--		P
MEMBRANIPORA PERFRAGILIS	--	--	--	P	--		P
FILICRISIA GENICULATA	--	--	--	P	--		P
ENIGMATICA						2	
ENIGMATIC	--	--	--	2	--		2
GRAND TOTALS 81	235[illegible]	2[illegible]9[illegible]	594[illegible]	5650	3564	21153	21153

STATION HP

PRELIMINARY SURVEY

TAXA	SAMPLE NO. 1	2	3	4	5	NUMBER OF GROUP	SPECIMENS TAXA
CNIDARIA						64	
CF DIADUMENE SP.	5	--	22	--	5		32
CF HALIPLANELLA SP.	3	2	1	12	14		32
HYDROZOA-UNIDENTIFIED SPP.	--	P	P	--	--		P
GONOTHYRAEA SP.	--	P	--	--	--		P
CALYPTOBLASTEA-UNIDENTIFIED SPP.	--	--	P	--	--		P
NEMERTEA						47	
NEMERTEA-UNIDENTIFIED SPP.	7	4	13	16	7		47
NEMATODA						13	
NEMATODA-UNIDENTIFIED SPP.	3	8	2	--	--		13
ANNELIDA-OLIGOCHAETA						14	
OLIGOCHAETA-UNIDENTIFIED SPP.	1	8	4	--	1		14
ANNELIDA-POLYCHAETA						1776	
CAPITELLIDAE-UNIDENTIFIED SPP.	1	--	--	--	--		1
MEDIOMASTUS CALIFORNIENSIS	29	80	91	2	55		247
THARYX SP., CF PARVUS	1	4	--	--	--		5
ASYCHIS SP.	4	4	3	--	4		15
POLYDORA SOCIALIS	1	--	2	2	--		5
STREBLOSPIO BENEDICTI	1	9	3	--	--		13
SCHISTOMERINGOS LONGICORNIS	2	--	--	--	--		2
NEPHTYS CORNUTA FRANCISCANA	1	--	1	--	1		3
EXOGONE LOUREI	65	291	889	--	159		1404
POLYCHAETA-UNIDENTIFIED JUVENILE	--	3	--	--	--		3
CAPITELLA CAPITATA	--	10	1	--	4		15
CIRRATULUS CIRRATUS	--	2	5	--	2		9
THARYX PARVUS	--	2	--	--	1		3
COSSURA PYGODACTYLATA	--	2	3	--	--		5
LANGERHANSIA SP.	--	1	--	--	--		1
MEDIOMASTUS SP., CF CALIFORNIENSIS	--	--	32	--	--		32
THARYX SP.	--	--	1	--	--		1
SPHAEROSYLLIS SP.	--	--	2	--	--		2
GLYCERA AMERICANA	--	--	--	1	--		1

HP
Survey P

STATION HP PRELIMINARY SURVEY (CONT.)

TAXA	SAMPLE NO. 1	2	3	4	5	NUMBER OF GROUP	SPECIMENS TAXA
ANAITIDES SP., CF WILLIAMSI - JUVENILE	--	--	--	1	--		1
HETEROMASTUS FILIFORMIS	--	--	--	--	2		2
ARMANDIA BREVIS	--	--	--	--	1		1
GYPTIS BREVIPALPA	--	--	--	--	1		1
CIRRATULUS CIRRATUS - JUVENILE	--	1	--	--	--		1
SCHISTOMERINGOS LONGICORNIS - JUVENILE	--	1	--	--	--		1
HETEROMASTUS FILIFORMIS - JUVENILE	--	--	--	--	1		1
? THARYX SP. - JUVENILE	--	--	--	--	1		1
SIPUNCULA						1	
SIPUNCULA-UNIDENTIFIED SPP.	--	--	--	1	--		1
ARTHROPODA						1165	
COROPHIUM SP. - JUVENILE	1	--	--	--	--		1
AMPELISCA MILLERI	130	180	412	248	124		1094
LEPTOCHELIA DUBIA	5	6	20	13	7		51
PYROMAIA TUBERCULATA	6	1	8	--	--		15
OSTRACODA-UNIDENTIFIED SPP.	--	1	--	--	--		1
UPOGEBIA SP.	--	1	--	--	--		1
CUMACEA-UNIDENTIFIED SP. B	--	--	1	--	--		1
EUDORELLA PACIFICA	--	--	1	--	--		1
MOLLUSCA						26	
GEMMA GEMMA	--	1	3	--	--		4
TRANSENNELLA TANTILLA	--	5	1	5	1		12
MUSCULUS SENHOUSIA	--	2	--	--	3		5
MACOMA ACOLASTA	--	--	1	--	--		1
ADULA DIEGENSIS	--	--	1	--	--		1
MYA ARENARIA	--	--	--	2	--		2
MYSELLA FERRUGINOSA	--	--	--	--	1		1
ECTOPROCTA						P	
BOWERBANKIA GRACILIS	--	P	--	--	--		P
CYCLOSTOMATA-UNIDENTIFIED SPP.	--	--	P	--	--		P
SCRUPOCELLARIA SP.	--	--	--	--	P		P
BUGULA SP.	--	--	--	--	P		P
ECHINODERMATA						4	
HOLOTHUROIDEA-UNIDENTIFIED SPP.	1	2	--	--	1		4
PHORONIDA						1	
PHORONIS SP.	1	--	--	--	--		1
GRAND TOTALS 57	268	631	1513	303	396	3111	3111

HP
Survey P

STATION SB-A

PRELIMINARY SURVEY

TAXA	SAMPLE NO. 1	2	3	4	NUMBER OF GROUP	SPECIMENS TAXA
CNIDARIA					5	
GONOTHYRAEA SP.	--	P	P	--		P
CF DIADUMENE SP.	--	--	3	--		3
CF HALIPLANELLA SP.	--	--	2	1		3
CALYPTOBLASTEA-UNIDENTIFIED SPP.	P	--	--	P		P
CNIDARIA-UNIDENTIFIED SPP.	--	P	P	--		P
NEMERTEA					22	
NEMERTEA-UNIDENTIFIED SPP.	2	1	2	17		22
NEMATODA					275	
NEMATODA-UNIDENTIFIED SPP.	--	169	94	12		275
ANNELIDA-OLIGOCHAETA					132	
OLIGOCHAETA-UNIDENTIFIED SPP.	--	66	31	35		132
ANNELIDA-POLYCHAETA					509	
PSEUDOPOLYDORA PAUCIBRANCHIATA	--	--	1	1		2
POLYNOIDAE-UNIDENTIFIED JUVENILE	1	--	--	--		1
HETEROMASTUS FILIFORMIS	17	60	67	15		159
MEDIOMASTUS CALIFORNIENSIS	11	--	--	--		11
COSSURA PYGODACTYLATA	3	9	14	4		30
ASYCHIS SP.	3	4	6	7		20
POLYDORA BRACHYCEPHALA	9	--	--	11		20
POLYDORA SP., NEAR SOCIALIS	1	--	--	--		1
EXOGONE LOUREI	54	31	83	60		228
SPHAEROSYLLIS SP.	1	--	--	--		1
CIRRATULUS CIRRATUS	--	6	3	--		9
HAPLOSCOLOPLOS PUGETTENSIS	--	4	3	--		7
GLYCINDE SP.	--	1	--	--		1
CIRRIFORMIA SPIRABRANCHA	--	--	1	--		1
PSEUDOPOLYDORA KEMPI CALIFORNICA	1	--	2	4		7
SCHISTOMERINGOS LONGICORNIS	--	--	6	--		6
STREBLOSPIO BENEDICTI	--	--	--	4		4

SB-A
Survey P

STATION SB-A ELIMINARY SURVEY (CONT.)

TAXA		SAMPLE NO. 1	2	3	4	NUMBER OF GROUP	SPECIMENS TAXA
ARTHROPODA						219	
AMPELISCA MILLERI		37	--	2	115		154
LEPTOCHELIA DUBIA		--	1	1	--		2
OSTRACODA-UNIDENTIFIED SPP.		--	--	6	44		50
COROPHIUM ACHERUSICUM		--	--	--	13		13
MOLLUSCA						318	
TAPES JAPONICA		14	52	30	17		113
MUSCULUS SENHOUSIA		22	104	49	25		200
UROSALPINX CINEREA		--	2	--	--		2
ISELICA OVOIDEA		--	1	--	--		1
ADULA DIEGENSIS		--	1	--	--		1
MACOMA NASUTA		--	--	1	--		1
ECTOPROCTA						P	
MEMBRANIPORA PERFRAGILIS		--	--	P	--		P
CHORDATA						5	
ASCIDIACEA-UNIDENTIFIED SPP.		--	1	3	--		4
STYELA SP.		--	--	1	--		1
ENIGMATICA						1	
ENIGMATICA		1	--	--	--		1
GRAND TOTALS	39	177	513	411	385	1486	1486

SB-B
Survey P

STATION SB-B

PRELIMINARY SURVEY

TAXA	SAMPLE NO. 1	2	3	4	5	NUMBER OF GROUP	SPECIMENS TAXA
PORIFERA						P	
KERATOSA-UNIDENTIFIED SPP.	P	--	--	--	--		P
CNIDARIA						11	
CF DIADUMENE SP.	1	--	--	--	--		1
CF HALIPLANELLA SP.	7	3	--	--	--		10
NEMERTEA						23	
NEMERTEA-UNIDENTIFIED SPP.	1	13	4	--	5		23
NEMATODA						285	
NEMATODA-UNIDENTIFIED SPP.	13	20	137	77	38		285
ANNELIDA-OLIGOCHAETA						461	
OLIGOCHAETA-UNIDENTIFIED SPP.	1	49	243	127	41		461
ANNELIDA-POLYCHAETA						1393	
CAPITELLA CAPITATA	--	1	2	1	2		6
HETEROMASTUS FILIFORMIS	--	8	12	3	17		40
COSSURA PYGODACTYLATA	--	2	4	1	--		[illegible]
ASYCHIS SP.	--	1	2	1	2		6
PSEUDOPOLYDORA KEMPI CALIFORNICA	--	1	--	--	--		1
PSEUDOPOLYDORA PAUCIBRANCHIATA	--	27	32	23	97		179
STREBLOSPIO BENEDICTI	--	1	1	--	1		3
NEPHTYS CAECOIDES	--	1	1	5	1		8
EXOGONE LOUREI	--	400	119	136	439		1094
SPHAEROSYLLIS SP.	--	1[illegible]	2	12	3		36
SCHISTOMERINGOS LONGICORNIS	--	--	2	--	--		2
MEDIOMASTUS CALIFORNIENSIS	--	--	--	1	--		1
ETEONE LONGA CALIFORNICA	--	--	--	1	--		1
SCHISTOMERINGOS LONGICORNIS - JUVENILE	--	--	1	--	--		1
? HAPLOSCOLOPLOS PUGETTENSIS	--	--	--	--	1		1
PSEUDOPOLYDORA SP., NEAR PAUCIBRANCHIATA	--	--	--	--	5		5
GLYCINDE SP.	--	--	--	--	2		2

SB-B
Survey P

STATION SB-B PRELIMINARY SURVEY (CONT.)

TAXA	SAMPLE NO. 1	2	3	4	5	NUMBER OF GROUP	SPECIMENS TAXA
ARTHROPODA						448	
OSTRACODA-UNIDENTIFIED SPP.	11	--	11	--	--		22
COROPHIUM ACHERUSICUM	39	1	75	39	4		158
GRANDIDIERELLA JAPONICA	1	3	1	1	1		7
AMPELISCA MILLERI	35	22	55	24	116		252
SYNIDOTEA LATICAUDA	--	1	--	--	--		1
CUMACEA-UNIDENTIFIED SP. A	--	--	1	--	--		1
COROPHIUM INSIDIOSUM	--	--	5	--	--		5
INSECTA-UNIDENTIFIED LARVA	--	--	--	1	--		1
SYNIDOTEA LATICAUDA - JUVENILE	--	--	--	1	--		1
MOLLUSCA						142	
MUSCULUS SENHOUSIA	34	32	14	13	6		99
TAPES JAPONICA	1	1	--	2	2		6
GEMMA GEMMA	2	1	1	8	2		14
CREPIDULA CONVEXA - JUVENILE	--	--	2	--	--		2
MACOMA NASUTA	--	--	--	1	--		1
ODOSTOMIA (EVALEA) SP.	9	--	--	--	--		9
ODOSTOMIA (EVALEA) FRANCISCANA	1	--	--	--	--		1
ODOSTOMIA (MENESTHO) FETELLA	1	--	--	--	--		1
UROSALPINX CINEREA	1	--	--	--	--		1
NASSARIUS OBSOLETUS	7	--	--	--	--		7
? OSTREA LURIDA - JUVENILE	--	--	--	--	1		1
ECTOPROCTA						P	
SMITTOIDEA PROLIFICA	--	--	--	P	--		P
CHORDATA						1	
ASCIDIACEA-UNIDENTIFIED SPP.	--	1	--	--	--		1
ENIGMATICA						1	
ENIGMATICA	--	--	1	--	--		1
GRAND TOTALS 46	165	608	728	478	786	2765	2765

RCH-A
Survey P

STATION RCH-A

PRELIMINARY SURVEY

TAXA	SAMPLE NO. 1	2	3	4	5	NUMBER OF GROUP	SPECIMENS TAXA
CNIDARIA						24	
CF DIADUMENE SP.	1	3	4	7	--		15
CF HALIPLANELLA SP.	1	2	--	6	--		9
GONOTHYRAEA SP.	P	P	--	P	P		P
PLATYHELMINTHES						1	
? ACOELA-UNIDENTIFIED SPP.	--	--	--	--	1		1
NEMERTEA						21	
NEMERTEA-UNIDENTIFIED SPP.	--	7	4	8	2		21
NEMATODA						58	
NEMATODA-UNIDENTIFIED SPP.	12	11	1	13	21		58
ANNELIDA-OLIGOCHAETA						78	
OLIGOCHAETA-UNIDENTIFIED SPP.	21	20	--	23	14		78
ANNELIDA-POLYCHAETA						394	
CAPITELLA CAPITATA	7	--	--	--	1		8
HETEROMASTUS FILIFORMIS	5	6	7	5	--		23
HETEROMASTUS SP. - JUVENILE	1	--	--	--	--		1
COSSURA PYGODACTYLATA	7	10	3	21	11		52
PSEUDOPOLYDORA PAUCIBRANCHIATA	15	19	--	48	10		92
SCHISTOMERINGOS LONGICORNIS	1	--	--	--	--		1
EXOGONE LOUREI	46	13	5	96	17		177
HAPLOSCOLOPLUS PUGETTENSIS	--	1	--	1	--		2
MARPHYSA SANGUINEA	--	1	--	--	--		1
GLYCINDE SP.	--	--	1	--	1		2
ASYCHIS SP.	--	2	--	12	5		19
PSEUDOPOLYDORA KEMPI CALIFORNICA	--	--	--	1	--		1
NEPHTYS CAECOIDES	--	--	--	1	--		1
SPHAEROSYLLIS SP.	--	--	--	--	2		2
DORVILLEIDAE-UNIDENTIFIED SPP.	--	1	--	--	--		1
CF THARYX	--	--	1	--	--		1

RCH-A
Survey P

STATION RCH-A PRELIMINARY SURVEY (CONT.)

TAXA	SAMPLE NO. 1	2	3	4	5	NUMBER OF GROUP	SPECIMENS TAXA
ARTHROPODA						351	
COROPHIUM INSIDIOSUM	1	1	--	1	--		3
AMPELISCA MILLERI	45	49	50	181	14		339
PYROMAIA TUBERCULATA	1	--	--	--	--		1
OSTRACODA-UNIDENTIFIED SPP.	--	4	--	2	--		6
LEPTOCHELIA DUBIA	--	--	1	--	--		1
COROPHIUM ACHERUSICUM	--	--	--	1	--		1
MOLLUSCA						05	
EPITONIUM TINCTUM	1	--	--	--	--		1
UROSALPINX CINEREA	5	--	--	--	--		5
NASSARIUS OBSOLETUS	2	--	--	--	--		2
ODOSTOMIA (MENESTHO) FETELLA	2	--	--	--	--		2
MYA ARENARIA	1	--	--	--	--		1
TAPES JAPONICA	12	7	21	18	15		73
GEMMA GEMMA	1	--	--	--	--		1
MUSCULUS SENHOUSIA	80	52	125	122	35		414
MACOMA NASUTA	--	1	1	2	--		4
MACOMA BALTHICA	--	--	1	--	--		1
ODOSTOMIA (EVALEA) SP., CF VALDEZI	1	--	--	--	--		1
CHORDATA						2	
ASCIDIACEA-UNIDENTIFIED SPP.	1	1	--	--	--		2
ENIGMATICA						1	
ENIGMATICA	--	1	--	--	--		1
GRAND TOTALS 42	270	212	225	569	149	1425	1425

STATION RCH-B

PRELIMINARY SURVEY

TAXA	SAMPLE NO. 1	2	3	4	5	NUMBER OF GROUP	SPECIMENS TAXA
CNIDARIA						32	
HYDROZOA-UNIDENTIFIED SPP.	P	--	--	--	--		P
CF DIADUMENE SP.	24	--	--	32	6		62
CF HALIPLANELLA SP.	8	1	--	1	10		20
GONOTHYRAEA SP.	--	P	--	P	P		P
CALYPTOBLASTEA-UNIDENTIFIED SPP.	P	--	P	P	--		P
NEMERTEA						32	
NEMERTEA-UNIDENTIFIED SPP.	14	6	--	6	6		32
NEMATODA						114	
NEMATODA-UNIDENTIFIED SPP.	88	1	--	4	21		114
ANNELIDA-OLIGOCHAETA						302	
OLIGOCHAETA-UNIDENTIFIED SPP.	135	26	--	54	87		302
ANNELIDA-POLYCHAETA						856	
HETEROMASTUS FILIFORMIS	80	57	74	52	70		333
COSSURA PYGODACTYLATA	11	7	--	--	5		23
COSSURA SP., CF PYGODACTYLATA	1	--	--	--	--		1
ASYCHIS SP.	2	30	--	8	12		52
HAPLOSCOLOPLOS PUGETTENSIS	3	--	2	--	--		5
POLYDORA SOCIALIS	1	--	--	--	--		1
PSEUDOPOLYDORA KEMPI CALIFORNICA	4	5	1	3	1		14
? PSEUDOPOLYDORA SP.	1	--	--	--	--		1
STREBLOSPIO BENEDICTI	2	1	--	--	--		3
SCHISTOMERINGOS LONGICORNIS	4	--	4	--	--		8
GLYCINDE SP.	1	--	--	1	--		2
HARMOTHOE IMBRICATA	1	--	1	--	--		2
EXOGONE LOUREI	192	34	--	62	68		356
SPHAEROSYLLIS SP.	1	--	--	--	5		6
POLYDORA BRACHYCEPHALA	--	6	--	1	--		7
POLYDORA SOCIALIS	--	3	--	--	3		6
PSEUDOPOLYDORA PAUCIBRANCHIATA	--	1	1	7	3		12
CIRRATULUS CIRRATUS	--	--	1	--	2		3
CIRRIFORMIA SPIRABRANCHA	--	--	1	--	--		1

RCH-B
Survey P

STATION RCH-B PRELIMINARY SURVEY (CONT.)

TAXA	SAMPLE NO. 1	2	3	4	5	NUMBER OF GROUP	SPECIMENS TAXA
POLYDORA SP., NEAR SOCIALIS	--	--	1	--	--		1
CHAETOZONE SP.	--	--	--	--	1		1
SCHISTOMERINGOS LONGICORNIS - JUVENILE	--	--	--	--	2		2
HETEROMASTUS FILIFORMIS - JUVENILE	1	--	--	--	--		1
CIRRATULUS CIRRATUS - JUVENILE	--	1	--	--	1		2
SCHISTOMERINGOS SP., NEAR LONGICORNIS	--	--	--	7	--		7
NEPHTYS SP., NEAR CAECOIDES	--	--	--	1	--		1
SIPUNCULA						1	
SIPUNCULA-UNIDENTIFIED SPP.	1	--	--	--	--		1
ARTHROPODA						104	
COPEPODA-UNIDENTIFIED SPP.	2	--	--	--	--		2
LEPTOCHELIA DUBIA	1	--	--	1	--		2
PYROMAIA TUBERCULATA	4	--	--	--	--		4
OSTRACODA-UNIDENTIFIED SPP.	--	9	--	1	--		10
AMPELISCA MILLERI	--	59	--	5	1		65
COROPHIUM ACHERUSICUM	--	--	--	1	--		1
COROPHIUM SP.	--	--	--	1	1		2
PYCNOGONIDA-UNIDENTIFIED SPP.	--	--	--	3	--		3
HYDRACARINA-UNIDENTIFIED SPP.	15	--	--	--	--		15
MOLLUSCA						455	
TAPES JAPONICA	22	14	9	24	22		91
MUSCULUS SENHOUSIA	146	7	11	89	107		360
ODOSTOMIA (EVALEA) VALDEZI	--	1	--	--	--		1
NASSARIUS OBSOLETUS	--	--	2	--	--		2
ISELICA OVOIDEA	--	--	--	--	1		1
CHORDATA						17	
UROCHORDATA-UNIDENTIFIED SPP.	6	--	--	7	--		13
STYELA SP.	--	--	--	1	--		1
ASCIDIACEA-UNIDENTIFIED SPP.	--	--	--	--	3		3
TUNICATA-UNIDENTIFIED SPP.	--	--	P	--	--		P
ENIGMATICA						2	
ENIGMATICA	1	--	--	--	1		2
GRAND TOTALS 54	772	269	108	377	439	1965	1965

STATION MIS-A

SURVEY NO. 1

TAXA	SAMPLE NO. 1	SAMPLE NO. 2	SAMPLE NO. 3	NUMBER OF GROUP	SPECIMENS TAXA
CNIDARIA				P	
HYDROZOA-UNIDENTIFIED SPP.	P	--	--		P
NEMATODA				269	
NEMATODA-UNIDENTIFIED SPP.	197	62	10		269
ANNELIDA-OLIGOCHAETA				7568	
OLIGOCHAETA-UNIDENTIFIED SPP.	4086	2255	1227		7568
ANNELIDA-POLYCHAETA				49	
STREBLOSPIO BENEDICTI	25	1	7		33
HAPLOSCOLOPLOS PUGETTENSIS	1	--	--		1
ETEONE LIGHTI	7	1	5		13
NEANTHES SUCCINEA	--	1	--		1
PSEUDOPOLYDORA KEMPI CALIFORNICA	--	--	1		1
ARTHROPODA				130	
COPEPODA-UNIDENTIFIED SPP.	33	80	1		114
AMPELISCA MILLERI	6	5	3		14
GRANDIDIERELLA JAPONICA	1	--	--		1
INSECTA-UNIDENTIFIED SPP.	1	--	--		1
MOLLUSCA				50	
MYA ARENARIA	1	--	2		3
MACOMA BALTHICA	14	9	10		33
NASSARIUS OBSOLETUS	2	6	--		8
ODOSTOMIA (EVALEA) SP. A	6	--	--		6
ECTOPROCTA				P	
MEMBRANIPORA PERFRAGILIS	P	--	--		P
GRAND TOTALS 17	4380	2427	1266	8066	8066

STATION MIS-B

SURVEY NO. 1

TAXA	SAMPLE NO. 3	4	5	NUMBER OF GROUP	SPECIMENS TAXA
NEMATODA				243	
NEMATODA-UNIDENTIFIED SPP.	159	83	1		243
ANNELIDA-OLIGOCHAETA				15122	
OLIGOCHAETA-UNIDENTIFIED SPP.	6580	6951	1591		15122
ANNELIDA-POLYCHAETA				317	
NEANTHES SUCCINEA	1	1	1		3
ETEONE LIGHTI	15	9	--		24
STREBLOSPIO BENEDICTI	101	164	17		282
PSEUDOPOLYDORA KEMPI CALIFORNICA	2	1	2		5
HETEROMASTUS FILIFORMIS	--	1	--		1
ETEONE SP., CF LIGHTI	--	--	2		2
ARTHROPODA				28	
COPEPODA-UNIDENTIFIED SPP.	3	15	1		19
AMPELISCA MILLERI	3	6	--		9
MOLLUSCA				63	
MACOMA BALTHICA	30	11	--		41
MYA ARENARIA	7	10	5		22
ECTOPROCTA				P	
MEMBRANIPORA PERFRAGILIS	P	P	--		P
GRAND TOTALS 13	6901	7252	1620	15773	15773

CS-A
Survey 1

STATION CS-A

SURVEY NO. 1

TAXA	SAMPLE NO. 1	3	4	NUMBER OF GROUP	SPECIMENS TAXA
CNIDARIA				P	
CF GONOTHYRAEA SP.	--	P	--		P
NEMATODA				45	
NEMATODA-UNIDENTIFIED SPP.	--	12	33		45
ANNELIDA-OLIGOCHAETA				387	
OLIGOCHAETA-UNIDENTIFIED SPP.	137	92	158		387
ANNELIDA-POLYCHAETA				114	
GLYCINDE SP.	1	11	6		18
NEANTHES SUCCINEA	2	--	--		2
STREBLOSPIO BENEDICTI	66	13	4		83
POLYDORA LIGNI	4	--	--		4
ETEONE LIGHTI	1	1	--		2
THARYX PARVUS	--	1	1		2
CAULLERIELLA HAMATA	--	1	--		2
POLYDORA BRACHYCEPHALA	--	--	1		1
EXOGONE LOUREI	--	--	1		1
ARTHROPODA				251	
PARAPHOXUS MILLERI	5	3	1		9
HYPERIIDEA-UNIDENTIFIED SPP.	1	--	--		1
COPEPODA-UNIDENTIFIED SPP.	1	--	--		1
AMPELISCA MILLERI	1	--	1		2
BALANUS IMPROVISUS	159	1	86		246
LEPTOCHELIA DUBIA	--	1	--		1
GRANDIDIERELLA JAPONICA	--	--	1		1
MOLLUSCA				33	
MACOMA BALTHICA	4	2	4		10
MYA ARENARIA	12	--	10		22
MUSCULUS SENHOUSIA	--	1	--		1

STATION CS-A SURVEY NO. 1 (CONT.)

TAXA		SAMPLE NO. 1	3	4	NUMBER OF GROUP	SPECIMENS TAXA
ECTOPROCTA					P	
MEMBRANIPORA PERFRAGILIS		--	--	P		P
ENIGMATICA					1	
ENIGMATICA		1	--	--		1
GRAND TOTALS	24	395	139	307	841	841

CS-B
Survey 1

STATION CS-B

SURVEY NO. 1

TAXA	SAMPLE NO. 1	2	3	NUMBER PER GROUP	SPECIMENS TAXA
NEMATODA				116	
NEMATODA-UNIDENTIFIED SPP.	75	--	41		116
ANNELIDA-OLIGOCHAETA				3435	
OLIGOCHAETA-UNIDENTIFIED SPP.	1592	351	1492		3435
ANNELIDA-POLYCHAETA				1095	
EXOGONE LOUREI	1	--	1		2
POLYDORA LIGNI	1	--	--		1
THARYX PARVUS	124	75	165		364
GLYCINDE SP.	24	26	14		64
STREBLOSPIO BENEDICTI	184	255	222		661
MEDIOMASTUS CALIFORNIENSIS	1	--	--		1
PSEUDOPOLYDORA KEMPI CALIFORNICA	--	1	--		1
HETEROMASTUS FILIFORMIS	--	1	--		1
ARTHROPODA				5	
PARAPHOXUS MILLERI	2	--	--		2
CAPRELLIDEA-UNIDENTIFIED SPP.	--	--	1		1
COROPHIUM SP., CF INSIDIOSUM	--	1	--		1
COPEPODA-UNIDENTIFIED SPP.	1	--	--		1
MOLLUSCA				92	
MACOMA BALTHICA	3	--	2		5
MYA ARENARIA	10	60	15		85
TAPES JAPONICA	--	1	--		1
ODOSTOMIA (MENESTHO) FETELLA	--	1	--		1
ECTOPROCTA				P	
MEMBRANIPORA PERFRAGILIS	--	P	--		P
GRAND TOTALS 19	2013	772	1953	4743	4743

ALC
Survey 1

STATION ALC

SURVEY NO. 1

TAXA	SAMPLE NO. 2	SAMPLE NO. 4	SAMPLE NO. 5	NUMBER OF GROUP	SPECIMENS TAXA
PORIFERA					
KERATOSA-UNIDENTIFIED SPP.	--	P	--	P	P
CNIDARIA					
CF HALIPLANELLA SP.	1	--	--	1	1
CALYPTOBLASTEA-UNIDENTIFIED SP. A	--	P	--		P
CALYPTOBLASTEA-UNIDENTIFIED SP. B	--	P	--		P
HYDROZOA-UNIDENTIFIED SPP.	--	--	P		P
PLATYHELMINTHES					
PLATYHELMINTHES-UNIDENTIFIED SPP.	--	--	2	2	2
NEMERTEA					
NEMERTEA-UNIDENTIFIFD SPP.	25	60	137	222	222
NEMATODA					
NEMATODA-UNIDENTIFIED SPP.	36	51	409	496	496
ANNELIDA-OLIGOCHAETA					
OLIGOCHAETA-UNIDENTIFIED SPP.	9	71	61	141	141
ANNELIDA-POLYCHAETA				11713	
MICROPHTHALMUS SP.	--	--	29		29
SPIOPHANES BOMBYX	--	--	1		1
POLYCHAETA-UNIDENTIFIED SPP.	--	--	2		2
POLYDORA SOCIALIS	1	--	--		1
GLYCERA TENUIS	5	20	20		45
HAPLOSCOLOPLOS PUGETTENSIS	1	--	--		1
SCOLELEPSIS SP., NEAR SQUAMATA	1	--	--		1
GLYCINDE SP.	2	3	--		5
ARMANDIA BREVIS	5	7	19		31
ETEONE DILATAE	1	--	--		1
HESIONURA SP.	572	2387	7340		10299
SYLLIDES SP.	20	599	646		1265

Table 59 (Continued)

Species	Test Duration	Concentration (mg/liter)	Results	Reference
Polychaeta				
Polychaetes (7 spp.)	96 hr	0.15-0.96	50% mortality	Reish, 1974
	28 days	0.03-0.65	50% mortality	
Nereis diversicolor	888 hr	0.1-0.7	41-828 hr mean survival time (from low-Cu area)	Bryan and Hummerstone, 1971
	888 hr	0.1-0.7	247-888 hr mean survival time (from high-Cu area)	
	408 hr	0.25-2.5	18-140 hr mean survival time (from low-Cu area)	
	408 hr	0.25-2.5	16-150 hr mean survival time (from low-Cu area)	
	408 hr	0.25-2.5	50-408 hr mean survival time (from high-Cu area)	
Nereis virens	21 days	< 0.1	100% survival	Raymont and Shields, 1963
	21 days	0.1	Toxicity threshold	
	21 days	0.4-0.5	100% mortality, 7 days	
	25 hr	0.18	Respiration rate increased 40%	
	4 days	0.18	Respiration rate increased >100%	
Oligochaeta				
Nais sp.	--	1.0-2.0	Lethal, 24 hr	Learner and Edwards, 1963
Limnodrilus hoffmeisteri	--	0.40	96-hr TLm (hard water)	Wurtz and Bridges, 1961
	--	0.38	24-hr TLm (hard water)	
Ectoprocta				
Bugula neritina (larvae)	--	< 0.2	Decreased growth and development	Miller, 1946
	--	0.2-0.3	Decreased growth and development	
	--	> 0.3	Decreased growth, larval death	
	--	3.8	50% larval mortality, 2 hr	Wisely and Blick, 1967

STATION ALC SURVEY NO. 1 (CONT.)

TAXA	SAMPLE NO. 2	4	5	NUMBER OF TAXA	SPECIMENS
ARCHIANNELIDA-UNIDENTIFIED SPP.	--	1	--		1
MEDIOMASTUS CALIFORNIENSIS	--	19	8		27
PRIONOSPIO SP.	--	1	--		1
THARYX SP., CF MONILARIS	--	1	--		1
POLYDORA BRACHYCEPHALA	--	--	1		1
EXOGONE LOUREI	--	--	1		1
ARTHROPODA				2	
PHOTIS BREVIPES	--	--	1		1
COPEPODA-UNIDENTIFIED SPP.	--	--	1		1
MOLLUSCA				137	
MACOMA NASUTA	--	1	--		1
TELLINA MODESTA	--	1	2		3
TRANSENNELLA TANTILLA	--	5	113		118
MYTILUS EDULIS	--	--	1		1
ADULA DIEGENSIS	--	--	31		31
TAPES JAPONICA	--	--	1		1
MYSELLA FERRUGINOSA	--	--	17		17
HIATELLA ARCTICA	--	--	3		3
MACOMA BALTHICA	--	--	3		3
FARTULUM SP.	--	--	3		3
ECTOPROCTA				[illegible]	
CHAPPERIA PALUTA	--	--	P		P
CRISIA MAXIMA	P	--	P		P
TRICELLARIA TERNATA	P	--	P		P
SCRUPOCELLARIA CALIFORNICA	--	P	P		P
HIPPOTHOA HYALINA	--	--	P		P
CALLOPORA SP.	--	--	P		P
TRICELLARIA OCCIDENTALIS	--	--	P		P
SCRUPOCELLARIA SP.	--	--	P		P
CHEILOPORA PRAELONGA	--	--	P		P
SMITTOIDEA PROLIFICA	--	--	P		P
MICROPORELLA CALIFORNICA	--	--	P		P
ELECTRA ARCTICA	--	--	P		P
CELLARIA SP.	--	--	P		P
PARASMITTINA TRISPINOSA	--	--	P		P

ALC
Survey 1

STATION ALC SURVEY NO. 1 (CONT.)

TAXA		SAMPLE NO. 1	2	3	4	5	NUMBER OF GROUP	SPECIMENS TAXA
HIPPCTHOA CORNUTA		--	--	P				P
LAGENIPORA PUNCTULATA		--	--	P				P
TEGELLA ARNIFERA		--	--	P				P
MEMBRANIPORA PERFRAGILIS		--	--	P				P
CRISIA UCCIDENTALIS		--	--	P				P
GRAND TOTALS	58	679	3227	8858			12764	12764

STATION OIH

SURVEY NO. 1

TAXA	SAMPLE NO. 2	3	6	NUMBER OF GROUP	SPECIMENS TAXA
PORIFERA				P	
KERATOSA-UNIDENTIFIED SPP.	--	--	P		P
CNIDARIA				4	
PENNATULACEA-UNIDENTIFIED SPP.	--	2	2		4
CNIDARIA-UNIDENTIFIED SPP.	--	--	P		P
NEMERTEA				12	
NEMERTEA-UNIDENTIFIED SPP.	8	3	1		12
NEMATODA				690	
NEMATODA-UNIDENTIFIED SPP.	64	226	400		690
ANNELIDA-OLIGOCHAETA				9396	
OLIGOCHAETA-UNIDENTIFIED SPP.	4381	2978	2037		9396
ANNELIDA-POLYCHAETA				13999	
PECTINARIA CALIFORNIENSIS	17	1	2		20
GLYCINDE SP.	55	5	5		65
ETEONE LONGA CALIFORNICA	26	18	18		62
CF HARMOTHOE SP.	1	--	--		1
NEPHTYS CAECOIDES	3	5	16		24
ETEONE LIGHTI	3	5	2		10
NEPHTYS CORNUTA FRANCISCANA	11	2	1		14
EXOGONE LOUREI	379	60	57		496
ASYCHIS SP.	5	--	1		6
SCHISTOMERINGOS LONGICORNIS	2	2	3		7
THARYX PARVUS	1	--	1		2
POLYDORA LIGNI	30	40	29		99
HARMOTHOE SP.	3	1	--		4
HAPLOSCOLOPLOS PUGETTENSIS	8	4	11		23
EUCHONE LIMNICOLA	14	2	--		16
STREBLOSPIO BENEDICTI	3883	4749	3985		12617
PSEUDOPOLYDORA PAUCIBRANCHIATA	339	13	5		376
PHOLOE MINUTA	2	5	6		13

OIH
Survey 1

OIH
Survey 1

STATION OIH SURVEY NO. 1 (CONT.)

TAXA	SAMPLE NO. 2	3	6	NUMBER OF GROUP	SPECIMENS TAXA
SCOLELEPSIS SQUAMATA	1	--	--		1
ETEONE DILATAE	1	--	--		1
SPHAEROSYLLIS SP.	99	--	--		99
NEPHTYS PARVA	4	10	--		14
ARMANDIA BREVIS	1	--	--		1
PSEUDOPOLYDORA KEMPI CALIFORNICA	4	3	3		10
SCOLELEPSIS SP., CF SQUAMATA	1	--	--		1
COSSURA PYGODACTYLATA	1	--	6		7
CAPITELLA CAPITATA	--	2	--		2
? PRONYSTIDES SP.	1	--	--		1
? PRIONOSPIO SP.	--	1	--		1
HARMOTHOE IMBRICATA	--	--	3		3
TROCHOCHAETA MULTISETOSUM	--	--	1		1
PRIONOSPIO SP.	1	--	1		2
ARTHROPODA				1212	
OSTRACODA-UNIDENTIFIED SPP.	207	72	31		310
SARSIELLA ZOSTERICOLA	1	--	--		1
LEPTOCHELIA DUBIA	11	--	--		11
EUDORELLA SP.	3	3	--		6
CUMELLA VULGARIS	237	50	15		302
ANTHURIDAE-UNIDENTIFIED SPP.	--	2	--		2
COPEPODA-UNIDENTIFIED SPP.	--	1	5		6
PINNIXA FRANCISCANA	7	2	6		15
PHOTIS BREVIPES	3	5	--		8
COROPHIUM ACHERUSICUM	4	--	--		4
GRANDIDIERELLA JAPONICA	8	1	--		9
AMPELISCA MILLERI	510	17	5		532
GAMMARIDAE-UNIDENTIFIED SPP.	--	1	--		1
AMPHIPODA-UNIDENTIFIED SPP.	--	3	--		3
SARSIELLA SP.	--	1	--		1
DECAPODA-UNIDENTIFIED LARVA	--	--	1		1
MOLLUSCA				3129	
GEMMA GEMMA	2608	239	61		2908
TRANSENNELLA TANTILLA	1	--	--		1
MUSCULUS SENHOUSIA	1	--	--		1
MACOMA NASUTA	105	59	37		201
MACOMA INQUINATA	4	2	--		6
MACOMA ACOLASTA	7	--	--		7
MYSELLA FERRUGINOSA	1	--	1		2
LYONSIA CALIFORNICA	1	1	--		2
TAPES JAPONICA	--	1	--		1

STATION OIH SURVEY NO. 1 (CONT.)

TAXA	SAMPLE NO. 2	3	6	NUMBER OF GROUP	SPECIMENS TAXA
ECTOPROCTA				P	
BUGULA NERITINA	P	P	P		P
BUGULA CALIFORNICA	P	--	--		P
TRICELLARIA TERNATA	--	P	--		P
BUGULA SP.	--	--	P		P
ECHINODERMATA				342	
HOLOTHUROIDEA-UNIDENTIFIED SPP.	206	88	47		341
CF LEPTOSYNAPTA SP.	--	--	1		1
GRAND TOTALS 69	13273	8705	6806	28784	28784

HP
Survey 1

STATION HP

SURVEY NO. 1

TAXA	SAMPLE NO. 3	5	6	NUMBER OF GROUP	SPECIMENS TAXA
CNIDARIA				26	
NEAR GONOTHYRAEA SP.	--	P	P		P
CF DIADUMENE SP.	4	--	--		4
CF HALIPLANELLA SP.	9	2	11		22
NEMERTEA				40	
NEMERTEA-UNIDENTIFIED SPP.	10	16	14		40
NEMATODA				109	
NEMATODA-UNIDENTIFIED SPP.	36	46	27		109
ANNELIDA-OLIGOCHAETA				61	
OLIGOCHAETA-UNIDENTIFIED SPP.	49	5	7		61
ANNELIDA-POLYCHAETA				1166	
THARYX PARVUS	13	9	8		30
CAPITELLA CAPITATA	6	4	4		14
ASYCHIS SP.	8	7	4		19
GLYCERA AMERICANA	1	2	--		3
MEDIOMASTUS CALIFORNIENSIS	124	65	52		241
ARMANDIA BREVIS	2	2	2		6
BOCCARDIA TRUNCATA	1	--	--		1
POLYDORA SP.	4	--	--		4
SCHISTOMERINGOS LONGICORNIS	2	--	--		2
ETEONE LONGA CALIFORNICA	1	--	--		1
CIRRATULUS CIRRATUS	5	1	--		6
SPHAEROSYLLIS SP.	8	--	--		8
STREBLOSPIO BENEDICTI	42	--	9		51
GLYCERA SP.	1	--	--		1
NEPHTYS CAECOIDES	1	--	--		1
EXOGONE LOUREI	411	183	160		754
COSSURA PYGODACTYLATA	1	1	--		2
NEPHTYS PARVA	1	--	--		1
NEPHTYS CORNUTA FRANCISCANA	2	--	--		2
PHOLOE MINUTA	1	--	--		1
HARMOTHOE IMBRICATA	1	1	--		2

STATION HP SURVEY NO. 1 (CONT.)

TAXA	SAMPLE NO. 3	SAMPLE NO. 5	SAMPLE NO. 6	NUMBER OF GROUP	SPECIMENS TAXA
POLYDORA SOCIALIS	1	2	--		3
GLYCINDE SP.	--	6	1		7
SPIOPHANES FIMBRIATA	--	1	--		1
HETEROMASTUS FILIFORMIS	--	--	4		4
POLYDORA SP., CF SOCIALIS	--	--	1		1
SIPUNCULA				1	
SIPUNCULA-UNIDENTIFIED SPP.	--	1	--		1
ARTHROPODA				9103	
AMPELISCA MILLERI	1952	2382	4501		8335
LEPTOCHELIA DUBIA	77	97	65		239
SAKSIELLA ZOSTERICOLA	--	1	4		5
COROPHIUM ACHERUSICUM	--	6	4		10
PYROMAIA TUBERCULATA	1	--	--		1
OSTRACODA-UNIDENTIFIED SPP.	4	--	--		4
COROPHIUM INSIDIOSUM	7	--	--		7
COROPHIUM SP.	2	--	--		2
MOLLUSCA				6	
PETRICOLA SP., CF CARDITOIDES	--	--	1		1
LYONSIA SP., CF CALIFORNICA	--	--	1		1
ADULA DIEGENSIS	1	--	--		1
MUSCULUS SENHOUSIA	1	--	--		1
TRANSENNELLA TANTILLA	--	1	--		1
MACOMA NASUTA	--	1	--		1
ECHINODERMATA				1	
HOLOTHUROIDEA-UNIDENTIFIED SPP.	--	--	1		1
PHORONIDA				1	
PHORONIS SP.	1	--	--		1
CHORDATA				P	
TUNICATA-UNIDENTIFIED SPP.	--	--	P		P
GRAND TOTALS 50	2791	2842	4881	10514	10514

HP
Survey 1

SB-A
Survey 1

STATION SB-A

SURVEY NO. 1

TAXA	SAMPLE NO. 2	3	4	NUMBER OF GROUP	SPECIMENS TAXA
CNIDARIA				2	
CNIDARIA-UNIDENTIFIED SPP.	--	1	--		1
CF GONOTHYRAEA SP.	P	--	--		P
CALYPTOBLASTEA-UNIDENTIFIED SPP.	--	P	--		P
CF HALIPLANELLA SP.	1	--	--		1
NEMATODA				22	
NEMATODA-UNIDENTIFIED SPP.	18	4	--		22
ANNELIDA-OLIGOCHAETA				357	
OLIGOCHAETA-UNIDENTIFIED SPP.	246	49	62		357
ANNELIDA-POLYCHAETA				2161	
POLYNOIDAE-UNIDENTIFIED JUVENILE	2	--	--		2
SPHAEROSYLLIS SP.	55	13	--		68
GLYCINDE SP.	3	1	3		7
HARMOTHOE IMBRICATA	2	1	--		3
CAPITELLA CAPITATA	3	3	9		15
ASYCHIS SP.	4	5	26		35
HAPLOSCOLOPLOS PUGETTENSIS	2	--	--		2
PSEUDOPOLYDORA KEMPI CALIFORNICA	10	5	2		17
COSSURA PYGODACTYLATA	2	3	--		5
STREBLOSPIO BENEDICTI	38	47	50		135
POLYDORA LIGNI	4	--	--		4
HETEROMASTUS FILIFORMIS	46	11	1		58
ETEONE LONGA CALIFORNICA	1	--	--		1
EXOGONE LOUREI	697	372	320		1389
AUTOLYTUS SP.	1	--	--		1
POLYDORA BRACHYCEPHALA	167	95	135		397
PSEUDOPOLYDORA PAUCIBRANCHIATA	1	--	--		1
POLYDORA SP.	1	--	--		1
CIRRATULUS CIRRATUS	--	1	--		1
SCHISTOMERINGOS LONGICORNIS	--	4	2		6
CF HARMOTHOE SP.	--	--	2		2
MEDIOMASTUS CALIFORNIENSIS	--	--	9		9
ETEONE DILATAE	--	--	2		2

STATION SB-A SURVEY NO. 1 (CONT.)

TAXA	SAMPLE NO. 2	3	4	NUMBER OF GROUP	SPECIMENS TAXA
ARTHROPODA				5876	
COPEPODA-UNIDENTIFIED SPP.	4	--	--		4
SARSIELLA ZOSTERICOLA	132	--	90		222
PYCNOGONIDA-UNIDENTIFIED SPP.	1	3	--		4
COROPHIUM ACHERUSICUM	3	7	4		14
AMPELISCA MILLERI	1140	2634	2757		6531
GRANDIDIERELLA JAPONICA	1	--	1		2
PARAPLEUSTES PUGETTENSIS	1	--	4		5
PYROMAIA TUBERCULATA	1	--	--		1
SYNIDOTEA LATICAUDA	5	14	12		31
LEPTOCHELIA DUBIA	1	1	3		5
CUMELLA VULGARIS	1	--	--		1
DECAPODA-UNIDENTIFIED SPP.	--	2	--		2
OSTRACODA-UNIDENTIFIED SPP.	--	54	--		54
MOLLUSCA				167	
MUSCULUS SENHOUSIA	3	3	2		8
TAPES JAPONICA	41	45	69		155
MACOMA NASUTA	1	--	--		1
ISELICA OVOIDEA	3	--	--		3
CHORDATA				95	
TUNICATA-UNIDENTIFIED SPP.	43	28	--		71
ASCIDIACEA-UNIDENTIFIED SPP.	--	--	24		24
GRAND TOTALS 48	2685	3406	3589	9680	9680

SB-A
Survey 1

SB-B
Survey 1

STATION SB-B

SURVEY NO. 1

TAXA	SAMPLE NO. 2	SAMPLE NO. 3	SAMPLE NO. 4	NUMBER OF GROUP	SPECIMENS TAXA
CNIDARIA				1	
CF DIADUMENE SP.	--	--	1		1
CF GONOTHYRAEA SP.	--	--	P		P
NEMERTEA				4	
NEMERTEA-UNIDENTIFIED SPP.	3	1	--		4
ANNELIDA-OLIGOCHAETA				65	
OLIGOCHAETA-UNIDENTIFIED SPP.	42	1	22		65
ANNELIDA-POLYCHAETA				697	
CIRRATULUS CIRRATUS	3	2	3		8
COSSURA PYGODACTYLATA	3	5	1		9
EXOGONE LOUREI	57	92	75		224
STREBLOSPIO BENEDICTI	35	23	13		71
ASYCHIS SP.	2	3	14		19
HETEROMASTUS FILIFORMIS	57	26	40		123
POLYDORA BRACHYCEPHALA	65	79	85		229
PSEUDOPOLYDORA KEMPI CALIFORNICA	--	5	--		5
SCHISTOMERINGOS LONGICORNIS	--	3	2		5
HARMOTHOE IMBRICATA	--	1	--		1
GLYCINDE SP.	--	1	--		1
CAPITELLA CAPITATA	--	2	--		2
ARTHROPODA				5401	
SARSIELLA ZOSTERICOLA	--	9	--		9
LEPTOCHELIA DUBIA	7	1	1		9
PYCNOGONIDA-UNIDENTIFIED SPP.	1	1	2		4
GRANDIDIERELLA JAPONICA	2	1	1		4
OSTRACODA-UNIDENTIFIED SPP.	22	--	14		36
AMPELISCA MILLERI	2055	2094	1074		5223
PARAPLEUSTES PUGETTENSIS	4	--	1		5
COROPHIUM INSIDIOSUM	1	2	--		3
ARACHNIDA-UNIDENTIFIED SPP.	1	--	--		1
SYNIDOTEA LATICAUDA	1	1	1		3
COROPHIUM ACHERUSICUM	2	1	1		4

STATION SB-B SURVEY NO. 1 (CONT.)

TAXA		SAMPLE NO. 2	3	4	NUMBER OF GROUP	SPECIMENS TAXA
MOLLUSCA					111	
MUSCULUS SENHOUSIA		9	3	--		12
ISELICA OVOIDEA		1	--	--		1
TAPES JAPONICA		30	24	40		94
GEMMA GEMMA		1	--	--		1
MYA ARENARIA		--	1	1		2
MACOMA NASUTA		--	--	1		1
CHORDATA					69	
ASCIDIACEA-UNIDENTIFIED SPP.		--	29	--		29
TUNICATA-UNIDENTIFIED SPP.		26	--	14		40
GRAND TOTALS	35	2430	2511	1407	6348	6348

STATION RCH-A

SURVEY NO. 1

TAXA	SAMPLE NO. 2	3	4	NUMBER OF GROUP	SPECIMENS TAXA
PROTOZOA				4	
FORAMINIFERA-UNIDENTIFIED SPP.	--	--	4		4
CNIDARIA				6	
CF GONOTHYRAEA SP.	--	--	P		P
CF HALIPLANELLA SP.	1	--	5		6
NEMERTEA				3	
NEMERTEA-UNIDENTIFIED SPP.	--	2	1		3
NEMATODA				741	
NEMATODA-UNIDENTIFIED SPP.	159	154	428		741
ANNELIDA-OLIGOCHAETA				2449	
OLIGOCHAETA-UNIDENTIFIED SPP.	889	508	1052		2449
ANNELIDA-POLYCHAETA				4472	
ETEONE LONGA CALIFORNICA	4	1	2		7
POLYNOIDAE-UNIDENTIFIED JUVENILE	1	--	--		1
MARPHYSA SANGUINEA	7	6	3		16
GLYCINDE SP.	2	2	2		6
POLYDORA BRACHYCEPHALA	2	2	--		4
HARMOTHOE IMBRICATA	3	4	6		13
HETEROMASTUS FILIFORMIS	83	33	69		185
STREBLOSPIO BENEDICTI	27	--	3		30
SPHAEROSYLLIS SP.	42	3	59		104
EXOGONE LOUREI	722	330	687		1739
PSEUDOPOLYDORA PAUCIBRANCHIATA	13	4	1		18
PSEUDOPOLYDORA KEMPI CALIFORNICA	1	3	--		4
POLYDORA LIGNI	116	44	98		258
POLYCIRRUS SP.	1123	630	326		2079
ASYCHIS SP.	--	1	3		4
CAPITELLA CAPITATA	--	--	1		1
SCHISTOMERINGOS SP.	--	--	1		1
POLYCHAETA-UNIDENTIFIED SPP.	--	--	1		1

STATION RCH-A SURVEY NO. 1 (CONT.)

TAXA	SAMPLE NO. 2	3	4	NUMBER OF GROUP	SPECIMENS TAXA
POLYCIRRUS SP., NEAR TENUISETIS	--	--	1		1
ARTHROPODA				11800	
SARSIELLA ZOSTERICOLA	93	--	73		166
INSECTA-UNIDENTIFIED SPP.	--	--	1		1
AMPELISCA MILLERI	7008	3318	1227		11553
GRANDIDIERELLA JAPONICA	4	8	4		16
COROPHIUM SP.	--	--	2		2
PARAPLEUSTES PUGETTENSIS	--	--	1		1
SYNIDOTEA SP., CF LATICAUDA	--	5	--		5
PYCNOGONIDA-UNIDENTIFIED SPP.	--	1	--		1
COROPHIUM ACHERUSICUM	15	--	--		15
COPEPODA-UNIDENTIFIED SPP.	1	2	1		4
CUMELLA VULGARIS	1	--	--		1
SYNIDOTEA LATICAUDA	7	--	12		19
COROPHIUM INSIDIOSUM	--	--	16		16
MOLLUSCA				196	
TAPES JAPONICA	12	7	28		47
MUSCULUS SENHOUSIA	--	6	135		141
UROSALPINX CINEREA	--	--	1		1
GEMMA GEMMA	--	--	1		1
CREPIDULA CONVEXA	--	--	6		6
ECTOPROCTA				P	
MEMBRANIPORA MEMBRANACEA	--	--	P		P
GRAND TOTALS 44	10336	5074	4261	19671	19671

STATION RCH-B SURVEY NO. 1 (CONT.)

TAXA		SAMPLE NO. 2	SAMPLE NO. 3	SAMPLE NO. 4	NUMBER OF GROUP	SPECIMENS TAXA
PHORONIDA					1	
CF PHORONOPSIS SP.		--	1	--		1
GRAND TOTALS	25	1531	652	154	2337	2337

STATION RCH-B

SURVEY NO. 1

TAXA	SAMPLE NO. 2	3	4	NUMBER OF GROUP	SPECIMENS TAXA
NEMERTEA				9	
NEMERTEA-UNIDENTIFIED SPP.	4	4	1		9
NEMATODA				47	
NEMATODA-UNIDENTIFIED SPP.	43	--	4		47
ANNELIDA-OLIGOCHAETA				129	
OLIGOCHAETA-UNIDENTIFIED SPP.	83	44	2		129
ANNELIDA-POLYCHAETA				895	
STREBLOSPIO BENEDICTI	537	142	14		693
HETEROMASTUS FILIFORMIS	33	13	16		62
PSEUDOPOLYDORA KEMPI CALIFORNICA	18	4	2		24
ASYCHIS SP.	1	1	--		2
COSSURA PYGODACTYLATA	42	4	--		46
PSEUDOPOLYDORA PAUCIBRANCHIATA	20	3	--		23
CAPITELLA CAPITATA	1	1	--		2
EXOGONE LOUREI	22	16	3		41
HAPLOSCOLOPLOS PUGETTENSIS	--	1	--		1
NEPHTYS CAECOIDES	--	--	1		1
ARTHROPODA				1225	
SYNIDOTEA BICUSPIDA	1	--	--		1
SARSIELLA ZOSTERICOLA	14	--	--		14
AMPELISCA MILLERI	698	393	104		1195
GRANDIDIERELLA JAPONICA	3	3	--		6
OSTRACODA-UNIDENTIFIED SPP.	--	6	1		7
SYNIDOTEA LATICAUDA	--	1	1		2
MOLLUSCA				31	
MUSCULUS SENHOUSIA	10	12	3		25
TAPES JAPONICA	1	1	1		3
MYA ARENARIA	--	1	--		1
MACOMA NASUTA	--	1	--		1
MACOMA BALTHICA	--	--	1		1

RCH-B
Survey 1

MIS-A
Survey 2

STATION MIS-A

SURVEY NO. 2

TAXA	SAMPLE NO. 1	2	3	NUMBER OF SPECIMENS GROUP	TAXA
CNIDARIA				P	
CAMPANULARIA SP.	P	P	P		P
HYDROZOA-UNIDENTIFIED SPP.	—	—	P		P
NEMATODA				61	
NEMATODA-UNIDENTIFIED SPP.	14	22	25		61
ANNELIDA-OLIGOCHAETA				259	
OLIGOCHAETA-UNIDENTIFIED SPP.	215	23	21		259
ANNELIDA-POLYCHAETA				4	
ETEONE LIGHTI	1	—	—		1
EXOGONE LOUREI	1	—	—		1
STREBLOSPIO BENEDICTI	—	—	1		1
ETEONE LONGA CALIFORNICA	—	—	1		1
ARTHROPODA				282	
SYNIDOTEA LATICAUDA	—	1	—		1
INSECTA-UNIDENTIFIED SPP.	—	1	—		1
COPEPODA-UNIDENTIFIED SPP.	56	131	92		279
BALANUS SP.	—	—	1		1
MOLLUSCA				22	
MYA ARENARIA	2	—	—		2
MACOMA BALTHICA	6	3	1		10
MUSCULUS SENHOUSIA	1	2	2		5
GEMMA GEMMA	1	—	—		1
NASSARIUS OBSOLETUS	2	1	—		3
ODOSTOMIA (MENESTHO) FETELLA	—	1	—		1
ECTOPROCTA				P	
MEMBRANIPORA PERFRAGILIS	P	P	P		P
GRAND TOTALS 19	299	185	144	628	628

STATION MIS-B

SURVEY NO. 2

TAXA	SAMPLE NO. 1	2	3	NUMBER OF SPECIMENS GROUP	TAXA
CNIDARIA				P	
HYDROZOA-UNIDENTIFIED SPP.	P	P	--		P
NEMATODA				25	
NEMATODA-UNIDENTIFIED SPP.	10	--	15		25
ANNELIDA-OLIGOCHAETA				14875	
OLIGOCHAETA-UNIDENTIFIED SPP.	4472	4565	5838		14875
ANNELIDA-POLYCHAETA				529	
STREBLOSPIO BENEDICTI	155	185	181		521
NEANTHES SUCCINEA	1	1	--		2
EXOGONE SP.	--	1	--		1
PSEUDOPOLYDORA KEMPI CALIFORNICA	--	4	1		5
ARTHROPODA				39	
PYCNOGONIDA-UNIDENTIFIED SPP.	--	1	--		1
GRANDIDIERELLA JAPONICA	--	1	--		1
MELITA SP.	--	2	--		2
COPEPODA-UNIDENTIFIED SPP.	--	--	35		35
MOLLUSCA				128	
MACOMA BALTHICA	7	9	7		23
MYA ARENARIA	5	24	2		31
NASSARIUS OBSOLETUS	3	69	1		73
GEMMA GEMMA	--	1	--		1
ECTOPROCTA				P	
MEMBRANIPORA PERFRAGILIS	--	--	P		P
GRAND TOTALS 16	4653	4863	6090	15596	15596

CS-A
Survey 2

STATION CS-A

SURVEY NO. 2

TAXA	SAMPLE NO. 1	2	3	NUMBER OF GROUP	SPECIMENS TAXA
CNIDARIA				P	
CAMPANULARIA SP.	P	--	P		P
NEMATODA				27	
NEMATODA-UNIDENTIFIED SPP.	5	4	18		27
ANNELIDA-OLIGOCHAETA				846	
OLIGOCHAETA-UNIDENTIFIED SPP.	191	338	317		846
ANNELIDA-POLYCHAETA				511	
ETEONE LONGA CALIFORNICA	2	1	--		3
ETEONE LIGHTI	1	2	7		10
STREBLOSPIO BENEDICTI	111	173	185		469
HETEROMASTUS FILIFORMIS	1	--	--		1
PSEUDOPOLYDORA KEMPI CALIFORNICA	1	2	--		3
THARYX PARVUS	1	--	--		1
POLYDORA LIGNI	1	3	1		5
GLYCINDE SP.	2	4	1		7
CHAETOZONE SP.	--	4	2		6
THARYX SP.	--	--	6		6
ARTHROPODA				9	
AMPELISCA MILLERI	--	1	--		1
GRANDIDIERELLA JAPONICA	8	--	--		8
MOLLUSCA				26	
MYA ARENARIA	2	6	2		10
MACOMA BALTHICA	2	2	2		6
NASSARIUS OBSOLETUS	6	--	2		8
ODOSTOMIA (MENESTHO) FETELLA	--	--	1		1
TAPES JAPONICA	--	--	1		1
GRAND TOTALS 20	334	540	545	1419	1419

STATION CS-8

SURVEY NO. 2

TAXA	SAMPLE NO. 1	SAMPLE NO. 2	SAMPLE NO. 3	NUMBER OF GROUP	SPECIMENS TAXA
CNIDARIA				P	
CAMPANULARIA SP.	--	P	P		P
NEMATODA				3	
NEMATODA-UNIDENTIFIED SPP.	1	--	2		3
ANNELIDA-OLIGOCHAETA				192	
OLIGOCHAETA-UNIDENTIFIED SPP.	30	11	151		192
ANNELIDA-POLYCHAETA				49	
NEANTHES SUCCINEA	1	--	1		2
STREBLOSPIO BENEDICTI	9	8	13		30
ETEONE LIGHTI	5	4	1		10
HETEROMASTUS FILIFORMIS	1	--	--		1
CHAETOZONE SP.	--	2	--		2
GLYCINDE SP.	--	--	4		4
ARTHROPODA				4	
AMPELISCA MILLERI	1	1	--		2
BALANUS SP., CF AMPHITRITE	--	--	2		2
MOLLUSCA				98	
GEMMA GEMMA	1	--	4		5
MACOMA BALTHICA	1	--	1		2
MYA ARENARIA	10	15	34		59
MYTILUS EDULIS	2	1	--		3
NASSARIUS OBSOLETUS	3	4	1		8
ODOSTOMIA (EVALEA) SP. A	3	2	4		9
ODOSTOMIA (MENESTHO) FETELLA	--	5	6		11
MUSCULUS SENHOUSIA	--	1	--		1
ECTOPROCTA				P	
MEMBRANIPORA PERFRAGILIS	--	P	--		P
GRAND TOTALS 20	68	54	224	346	346

CS-B
Survey 2

ALC
Survey 2

STATION ALC

SURVEY NO. 2

TAXA	SAMPLE NO. 1	2	3	NUMBER OF GROUP	SPECIMENS TAXA
PROTOZOA					
FORAMINIFERA-UNIDENTIFIED SPP.	--	--	4	4	4
CNIDARIA				2	
DIADUMENE SP.	--	--	1		1
HALIPLANELLA SP.	--	--	1		1
CAMPANULARIA SP.	--	--	P		P
PLATYHELMINTHES					
PLATYHELMINTHES-UNIDENTIFIED SPP.	--	--	1	1	1
NEMERTEA					
NEMERTEA-UNIDENTIFIED SPP.	1	5	19	25	25
NEMATODA					
NEMATODA-UNIDENTIFIED SPP.	--	51	16	67	67
ANNELIDA-OLIGOCHAETA					
OLIGOCHAETA-UNIDENTIFIED SPP.	--	33	9	42	42
ANNELIDA-POLYCHAETA				314	
ANAITIDES SP.	51	--	--		51
EXOGONE LOUREI	1	5	8		14
CAPITELLA CAPITATA	1	--	3		4
EUMIDA SP.	1	--	--		1
ARMANDIA BREVIS	1	2	10		13
GLYCINDE SP.	1	6	1		8
GLYCERA AMERICANA	--	1	--		1
COSSURA PYGODACTYLATA	--	1	--		1
ETEONE LONGA CALIFORNICA	--	1	--		1
STREBLOSPIO BENEDICTI	--	8	1		9
PECTINARIA CALIFORNIENSIS	--	1	--		1
ANAITIDES WILLIAMSI	--	31	--		31
ANAITIDES WILLIAMSI-JUVENILE	--	2	--		2

ALC
Survey 2

STATION ALC SURVEY NO. 2 (CONT.)

TAXA	SAMPLE NO. 1	SAMPLE NO. 2	SAMPLE NO. 3	NUMBER OF GROUP	SPECIMENS TAXA
GYPTIS BREVIPALPA	--	1	--		1
HESIONURA SP.	--	2	10		12
MEDIOMASTUS CALIFORNIENSIS	--	7	4		11
HETEROMASTUS FILIFORMIS	--	1	--		1
LUMBRINERIS SP.	--	--	1		1
PHYLLODOCIDAE-UNIDENTIFIED JUVENILE	--	--	1		1
NEAR EUMIDA SANGUINEA	--	--	1		1
SPIOPHANES SP.	--	--	1		1
NEREIS LATESCENS	--	--	1		1
ANAITIDES SP., NEAR WILLIAMSI	--	--	60		60
EULALIA AVICULISETA	--	1	--		1
POLYCIRRUS CALIFORNICUS	--	1	--		1
PRIONOSPIO CIRRIFERA	--	3	--		3
CHONE MINUTA	--	1	--		1
THARYX SP.	--	2	1		3
PALEANOTUS BELLIS	--	1	--		1
POLYDORA CAULLERYI	24	9	31		64
STREPTOSYLLIS SP.	--	1	3		4
CHONE MOLLIS	1	--	--		1
LUMBRINERIS TETRAURA - JUVENILE	--	--	1		1
LUMBRINERIS TETRAURA	--	1	2		3
SYLLIDES SP.	--	1	--		1
NEANTHES SUCCINEA	--	3	--		3
ARTHROPODA				249	
PHOTIS BREVIPES	11	95	35		141
MELITA DENTATA	1	--	--		1
ISCHYROCERUS ANGUIPES	1	--	--		1
COROPHIUM ACHERUSICUM	8	--	--		8
PARAPLEUSTES PUGETTENSIS	8	16	2		26
MELITA SP.	2	--	--		2
CANCER SP., CF ANTENNARIUS	1	--	--		1
LEPTOCHELIA DUBIA	--	1	4		5
COPEPODA-UNIDENTIFIED SPP.	--	6	2		8
AMPELISCA MILLERI	--	19	7		26
BRACHYURA-UNIDENTIFIED SPP.	--	--	1		1
GRANDIDIERELLA JAPONICA	--	--	1		1
SYNIDOTEA BICUSPIDA	--	3	--		3
PROTOMEDEIA ZOTEA	--	2	--		2
STENOTHOIDES SP.	--	1	--		1
AMPHIPODA-UNIDENTIFIED SPP.	--	3	--		3
AEGINELLIDAE-UNIDENTIFIED SPP.	--	1	--		1
MELITA SP., CF SULCA	--	2	--		2
ASELLOTA-UNIDENTIFIED SPP.	--	1	--		1
TIRON BIOCELLATA	--	5	--		5

ALC
Survey 2

STATION ALC SURVEY NO. 2 (CONT.)

TAXA		SAMPLE NO. 1	2	3	NUMBER OF GROUP	SPECIMENS TAXA
CANCER ANTENNARIUS		--	2	--		2
BRACHYURA-UNIDENTIFIED JUVENILE		--	2	--		2
PINNIXA FRANCISCANA		--	1	--		1
DULICHIA SP.		--	1	--		1
PODOCERUS SP.		--	1	--		1
UPOGEBIA PUGETTENSIS		--	1	--		1
CAPRELLA SP.		--	--	2		2
MOLLUSCA					176	
ZIRFAEA PILSBRYI		16	11	65		92
MACOMA BALTHICA		2	--	--		2
ODOSTOMIA (EVALEA) FRANCISCANA		1	8	22		31
PROTOTHACA STAMINEA		--	3	1		4
TRANSENNELLA TANTILLA		--	2	6		8
MYTILUS EDULIS		--	2	1		3
MACOMA NASUTA		--	18	--		18
PLATYODON CANCELLATUS		--	--	1		1
ADULA DIEGENSIS		--	--	8		8
MACOMA INQUINATA		--	--	10		10
NASSARIUS MENDICUS		--	--	1		1
ECTOPROCTA					P	
SCRUPOCELLARIA SP.		P	--	P		P
BUGULA SP.		--	--	P		P
FILICRISIA SP.		--	--	P		P
HIPPOTHOA HYALINA		--	--	P		P
ENIGMATICA					6	
ENIGMATICA		1	1	4		6
GRAND TOTALS	87	134	390	364	998	888

OIH
Survey 2

STATION OIH

SURVEY NO. 2

TAXA	SAMPLE NO. 1	2	3	NUMBER OF GROUP	SPECIMENS TAXA
PROTOZOA				14	
FORAMINIFERA-UNIDENTIFIED SPP.	8	2	4		14
CNIDARIA				40	
STYLATULA ELONGATA	17	10	13		40
HYDROZOA-UNIDENTIFIED SPP.	P	P	--		P
NEMERTEA				26	
NEMERTEA-UNIDENTIFIED SPP.	12	8	6		26
NEMATODA				1347	
NEMATODA-UNIDENTIFIED SPP.	813	211	323		1347
ANNELIDA-OLIGOCHAETA				12244	
OLIGOCHAETA-UNIDENTIFIED SPP.	4989	4438	2817		12244
ANNELIDA-POLYCHAETA				23930	
GLYCINDE SP.	12	32	23		67
ETEONE LIGHTI	2	--	5		7
NEPHTYS CAECOIDES	15	13	8		36
NEPHTYS CORNUTA FRANCISCANA	13	9	13		35
PSEUDOPOLYDORA KEMPI CALIFORNICA	3	6	1		10
STREBLOSPIO BENEDICTI	8247	5539	7510		21296
PSEUDOPOLYDORA PAUCIBRANCHIATA	249	259	277		785
POLYDORA LIGNI	8	5	11		24
PHOLOE MINUTA	5	2	8		15
NEPHTYS PARVA	1	2	1		4
ETEONE SP., CF LONGA CALIFORNICA	3	--	--		3
HAPLOSCOLOPLOS PUGETTENSIS	6	6	5		17
ANAITIDES SP.	1	--	--		1
SPHAEROSYLLIS SP.	142	79	177		398
HETEROMASTUS FILIFORMIS	3	--	--		3
CAPITELLA CAPITATA	2	--	3		5
MEDIOMASTUS CALIFORNIENSIS	1	1	3		5
PECTINARIA CALIFORNIENSIS	9	16	7		32

OIH
Survey 2

STATION OIH SURVEY NO. 2 (CONT.)

TAXA	SAMPLE NO. 1	SAMPLE NO. 2	SAMPLE NO. 3	NUMBER OF GROUP	SPECIMENS TAXA
CHAETOZONE SP.	1	1	1		3
EXOGONE LOUREI	395	309	398		1102
ETEONE LONGA CALIFORNICA	16	2	13		31
NEPHTYS CAECOIDES - JUVENILE	--	1	--		1
ARMANDIA BREVIS	--	1	--		1
COSSURA PYGODACTYLATA	--	1	--		1
THARYX PARVUS	--	1	--		1
HARMOTHOE SP.	--	2	--		2
EUCHONE LIMNICOLA	5	11	7		23
HARMOTHOE IMBRICATA	--	--	3		3
CIRRATULUS CIRRATUS	--	--	2		2
CHONE GRACILIS	1	--	1		2
THARYX SP.	2	--	--		2
MELINNAMPHARETE GRACILIS	1	--	--		1
EUNIDA BIFOLIATA	--	--	1		1
SCHISTOMERINGOS SP. - JUVENILE	2	--	--		2
SCOLELEPSIS SQUAMATA	2	1	2		5
ASYCHIS SP.	2	--	--		2
SCHISTOMERINGOS LONGICORNIS	--	1	1		2
ARTHROPODA				863	
GRANDIDIERELLA JAPONICA	--	9	6		15
PHOTIS SP.	56	--	2		58
LEPTOCHELIA DUBIA	--	1	2		3
CUMELLA VULGARIS	--	41	87		128
PINNIXA FRANCISCANA	--	--	4		4
DECAPODA-UNIDENTIFIED LARVA	--	--	5		5
SARSIELLA ZOSTERICOLA	176	142	246		564
AMPELISCA MILLERI	--	42	36		78
SYNIDOTEA LATICAUDA	--	1	2		3
COPEPODA-UNIDENTIFIED SPP.	2	--	--		2
BALANUS CRENATUS	1	1	--		2
PYCNOGONIDA-UNIDENTIFIED SPP.	--	1	--		1
MOLLUSCA				3079	
GEMMA GEMMA	1046	700	1201		2947
MACOMA NASUTA	49	31	32		112
MACOMA ACOLASTA	1	--	1		2
TELLINA MODESTA	1	--	1		2
MYSELLA FERRUGINOSA	4	--	3		7
MUSCULUS SENHOUSIA	1	--	2		3
MYTILUS EDULIS	--	2	1		3
MACOMA INQUINATA	--	--	3		3

OIH
Survey 2

STATION OIH SURVEY NO. 2 (CONT.)

TAXA		SAMPLE NO. 1	2	3	NUMBER OF GROUP	SPECIMENS TAXA
ECTOPROCTA					P	
BUGULA NERITINA		P	P	--		P
TRICELLARIA SP.		--	P	--		P
CRYPTOSULA PALLASIANA		--	P	--		P
CRISIA MAXIMA		--	P	--		P
FILICRISIA SP.		P	--	--		P
ECHINODERMATA					223	
HOLOTHUROIDEA-UNIDENTIFIED SPP.		116	68	39		223
CHORDATA					2	
CIONA INTESTINALIS		2	--	--		2
ENIGMATICA					4	
ENIGMATICA		--	--	4		4
GRAND TOTALS	71	16443	12008	13321	41772	41772

STATION HP

SURVEY NO. 2

TAXA	SAMPLE NO. 1	SAMPLE NO. 2	SAMPLE NO. 3	NUMBER OF GROUP	SPECIMENS TAXA
PROTOZOA				1	
FORAMINIFERA-UNIDENTIFIED SPP.	1	--	--		1
CNIDARIA				97	
HALIPLANELLA SP.	13	6	4		23
CAMPANULARIA SP.	P	P	P		P
DIADUMENE SP.	1	73	--		74
NEMERTEA				48	
NEMERTEA-UNIDENTIFIED SPP.	12	19	17		48
NEMATODA				80	
NEMATODA-UNIDENTIFIED SPP.	38	26	16		80
ANNELIDA-OLIGOCHAETA				141	
OLIGOCHAETA-UNIDENTIFIED SPP.	53	38	50		141
ANNELIDA-POLYCHAETA				1391	
CIRRATULUS CIRRATUS	2	2	3		7
ASYCHIS SP.	11	13	7		31
MEDIOMASTUS CALIFORNIENSIS	232	258	172		662
EXOGONE LOUREI	283	192	72		547
GLYCINDE SP.	1	--	--		1
CAPITITA AMBISETA	1	--	--		1
POLYDORA SOCIALIS	5	6	--		11
EXOGONE SP.	1	--	--		1
SPHAEROSYLLIS SP.	1	8	--		9
AUTOLYTUS SP.	1	--	--		1
COSSURA PYGODACTYLATA	2	1	1		4
ARMANDIA BREVIS	7	9	3		19
STREBLOSPIO BENEDICTI	1	8	--		9
NEPHTYS CORNUTA FRANCISCANA	4	5	1		10
THARYX PARVUS	14	30	11		55
ETEONE SP., CF LONGA CALIFORNICA	--	1	--		1
GLYCINDE SP. - JUVENILE	--	2	--		2

HP
Survey 2

STATION HP   SURVEY NO. 2 (CONT.)

TAXA	SAMPLE NO. 1	SAMPLE NO. 2	SAMPLE NO. 3	NUMBER OF GROUP	SPECIMENS TAXA
PSEUDOPOLYDORA PAUCIBRANCHIATA	--	1	--		1
POLYNOIDAE-UNIDENTIFIED JUVENILE	--	1	--		1
DISOMA MULTISETOSUM	--	1	1		2
CHAETOZONE SP.	--	--	1		1
HAPLOSCOLOPLOS PUGETTENSIS	--	--	1		1
CAPITELLA CAPITATA	--	--	2		2
PHOLOE MINUTA	--	--	1		1
POLYDORA SP.	--	--	3		3
SPIOPHANES FIMBRIATA	--	--	1		1
PRIONOSPIO CIRRIFERA	--	2	--		2
ETEONE DILATAE	2	--	--		2
SCHISTOMERINGOS LONGICORNIS	1	1	1		3
ARTHROPODA				168	
AMPELISCA MILLERI	21	17	4		42
LEPTOCHELIA DUBIA	18	25	20		63
SARSIELLA ZOSTERICOLA	17	28	7		52
BALANUS CRENATUS	6	--	1		7
PYROMAIA TUBERCULATA	1	--	--		1
PHOTIS SP.	--	1	--		1
COROPHIUM ACHERUSICUM	--	--	1		1
ACARINA-UNIDENTIFIED SPP.	--	--	1		1
MOLLUSCA				13	
MACOMA BALTHICA	1	--	--		1
PODODESMUS SP. - JUVENILE	1	--	--		1
MYTILUS EDULIS	1	--	--		1
ALVINIA COMPACTA	3	--	--		3
PROTOTHACA STAMINEA	--	1	--		1
TAPES JAPONICA	--	1	--		1
GEMMA GEMMA	--	1	--		1
MYSELLA FERRUGINOSA	--	1	1		2
MUSCULUS SENHOUSIA	--	--	1		1
MACOMA INQUINATA	--	--	1		1
ECTOPROCTA				P	
HIPPOTHOA HYALINA	P	P	P		P
SMITTOIDEA PROLIFICA	P	--	P		P
ELECTRA ARCTICA	--	--	P		P
ALCYONIDIUM PARASITICUM	--	--	P		P
ANASCA-UNIDENTIFIED SPP.	P	--	--		P

HP
Survey 2

STATION HP SURVEY NO. 2 (CONT.)

TAXA		SAMPLE NO. 1	2	3	NUMBER OF GROUP	SPECIMENS TAXA
PHORONIDA					5	
PHORONIS SP.		2	--	--		2
PHORONOPSIS VIRIDIS		--	3	--		3
ENIGMATICA					1	
ENIGMATICA		1	--	--		1
GRAND TOTALS	62	759	781	405	1945	1945

SB-A
Survey 2

STATION SB-A

SURVEY NO. 2

TAXA	SAMPLE NO. 1	2	4	NUMBER OF GROUP	SPECIMENS TAXA
PROTOZOA				13	
FORAMINIFERA-UNIDENTIFIED SPP.	1	8	4		13
CNIDARIA				22	
DIADUMENE SP.	1	--	2		3
CAMPANULARIA SP.	P	--	P		P
HALIPLANELLA SP.	--	--	19		19
NEMERTEA				6	
NEMERTEA-UNIDENTIFIED SPP.	--	--	6		6
NEMATODA				1974	
NEMATODA-UNIDENTIFIED SPP.	652	540	782		1974
ANNELIDA-OLIGOCHAETA				4041	
OLIGOCHAETA-UNIDENTIFIED SPP.	1908	714	1419		4041
ANNELIDA-POLYCHAETA				1551	
HAPLOSCOLOPLOS PUGETTENSIS	3	1	--		4
GLYCINDE SP.	1	2	--		3
STREBLOSPIO BENEDICTI	47	21	16		84
SPHAEROSYLLIS SP.	33	12	99		144
EXOGONE LOUREI	339	348	231		918
COSSURA PYGODACTYLATA	15	8	1		24
THARYX PARVUS	7	1	--		8
ETEONE LIGHTI	1	--	2		3
ASYCHIS SP.	1	1	1		3
HARMOTHOE IMBRICATA	1	1	1		3
PSEUDOPOLYDORA KEMPI CALIFORNICA	63	39	3		105
HETEROMASTUS FILIFORMIS	44	54	66		164
CAPITELLA CAPITATA	1	18	7		26
PSEUDOPOLYDORA PAUCIBRANCHIATA	--	1	--		1
POLYDORA LIGNI	--	--	3		3
ETEONE LONGA CALIFORNICA	--	--	1		1
AUTOLYTUS SP.	--	--	2		2

SB-A
Survey 2

STATION SB-A SURVEY NO. 2 (CONT.)

TAXA	SAMPLE NO. 1	SAMPLE NO. 2	SAMPLE NO. 4	NUMBER OF GROUP	SPECIMENS TAXA
THARYX SP.	--	--	3		3
HARMOTHOE SP. - JUVENILE	1	--	--		1
SCHISTOMERINGOS LONGICORNIS	7	2	2		11
POLYDORA CAULLERYI	6	25	5		36
HARMOTHOE SP.	--	--	1		1
MARPHYSA SANGUINEA	2	--	1		3
ARTHROPODA				291	
AMPELISCA MILLERI	4	51	5		60
PARAPLEUSTES PUGETTENSIS	1	1	--		2
GRANDIDIERELLA JAPONICA	--	2	1		3
ACARINA-UNIDENTIFIED SPP.	--	14	29		43
COPEPODA-UNIDENTIFIED SPP.	8	1	15		24
COROPHIUM ACHERUSICUM	--	--	4		4
SYNIDOTEA LATICAUDA	2	--	2		4
PYCNOGONIDA-UNIDENTIFIED JUVENILE	1	--	--		1
SARSIELLA ZOSTERICOLA	39	7	102		148
COROPHIUM INSIDIOSUM	1	--	--		1
OSTRACODA-UNIDENTIFIED SPP.	1	--	--		1
MOLLUSCA				938	
MUSCULUS SENHOUSIA	1	--	--		1
TAPES JAPONICA	168	189	434		791
GEMMA GEMMA	1	15	44		60
ISELICA OVOIDEA	15	19	35		69
MYA ARENARIA	--	2	--		2
MACOMA NASUTA	--	2	--		2
CREPIDULA CONVE.	--	1	3		4
ODOSTOMIA (MENESTHO) FETELLA	--	1	--		1
OSTREA LURIDA - JUVENILE	--	--	1		1
MACOMA BALTHICA	--	--	2		2
NUDIBRANCHIA-UNIDENTIFIED SPP.	--	--	5		5
ECTOPROCTA				P	
MEMBRANIPORELLA SP.	--	--	P		P
CONOPEUM RETICULUM	--	--	P		P
CHEILOSTOMATA-UNIDENTIFIED SPP.	--	--	P		P
CHORDATA				23	
CIONA INTESTINALIS	7	--	16		23
GRAND TOTALS 56	3383	2101	3375	8859	8859

STATION SB-B

SURVEY NO. 2

TAXA	SAMPLE NO. 1	2	3	NUMBER OF GROUP	SPECIMENS TAXA
CNIDARIA				P	
CAMPANULARIA SP.	P	P	P		P
NEMERTEA				1	
NEMERTEA-UNIDENTIFIED SPP.	1	--	--		1
NEMATODA				962	
NEMATODA-UNIDENTIFIED SPP.	917	15	30		962
ANNELIDA-OLIGOCHAETA				2125	
OLIGOCHAETA-UNIDENTIFIED SPP.	1345	467	313		2125
ANNELIDA-POLYCHAETA				4808	
HARMOTHOE IMBRICATA	4	--	1		5
HAPLOSCOLOPLOS PUGETTENSIS	8	2	1		11
ETEONE LIGHTI	4	4	12		20
STREBLOSPIO BENEDICTI	3	59	721		783
ASYCHIS SP.	11	58	33		102
COSSURA PYGODACTYLATA	42	37	37		116
PSEUDOPOLYDORA PAUCIBRANCHIATA	2	--	--		2
PSEUDOPOLYDORA KEMPI CALIFORNICA	4	17	63		84
POLYDORA LIGNI	15	54	137		206
SPHAEROSYLLIS SP.	252	4	18		274
EXOGONE LOUREI	1683	204	272		2159
HETEROMASTUS FILIFORMIS	293	109	96		498
CIRRATULUS CIRRATUS	286	47	28		361
CAPITELLA CAPITATA	8	2	1		11
ETEONE LONGA CALIFORNICA	--	12	16		28
GLYCINDE SP.	--	1	--		1
POLYNOIDAE-UNIDENTIFIED JUVENILE	--	1	1		2
CIRRIFORMIA SPIRABRANCHA	--	--	1		1
LUMBRINERIDAE-UNIDENTIFIED SPP.	--	--	1		1
NEPHTYS CORNUTA FRANCISCANA	--	--	1		1
SCHISTOMERINGOS LONGICORNIS	68	29	2		99
SCHISTOMERINGOS SP. - JUVENILE	--	--	4		4
LYSIDICE NINETTA	28	1	1		30

SB-B
Survey 2

SB-B
Survey 2

STATION SB-8 SURVEY NO. 2 (CONT.)

TAXA	SAMPLE NO. 1	2	3	NUMBER OF GROUP	SPECIMENS TAXA
POLYDORA CAECA	2	--	--		2
AUTOLYTUS SP.	--	3	--		3
EUMIDA SP.	--	1	--		1
HARMOTHOE SP.	--	--	1		1
THARYX SP. - JUVENILE	--	--	1		1
CHAETOZONE SP. - JUVENILE	--	--	1		1
ARTHROPODA				2733	
LIMNORIA QUADRIPUNCTATA	1	--	--		1
COROPHIUM ACHERUSICUM	2	--	--		2
COPEPODA-UNIDENTIFIED SPP.	270	1	--		271
LEPTOCHELIA DUBIA	75	2	1		78
PYCNOGONIDA-UNIDENTIFIED SPP.	6	--	1		7
ACARINA-UNIDENTIFIED SPP.	1856	--	--		1856
AMPELISCA MILLERI	5	49	291		345
GRANDIDIERELLA JAPONICA	--	3	2		5
SARSIELLA SP.	--	25	--		25
CIRRIPEDIA-UNIDENTIFIED SPP.	--	1	--		1
COROPHIUM SP.	--	1	--		1
CIRRIPEDIA-UNIDENTIFIED LARVA	--	20	--		20
SARSIELLA ZOSTERICOLA	62	--	59		121
MOLLUSCA				336	
MUSCULUS SENHOUSIA	164	26	15		205
MYA ARENARIA	1	--	--		1
TAPES JAPONICA	71	30	10		111
MACOMA BALTHICA	1	--	--		1
ISELICA OVOIDEA	6	3	--		9
CREPIDULA CONVEXA	6	--	--		6
OSTREA LURIDA	--	1	--		1
GEMMA GEMMA	--	--	1		1
MACOMA NASUTA	--	--	1		1
ECTOPROCTA				P	
SMITTOIDEA PROLIFICA	P	--	--		P
CONOPEUM RETICULUM	P	--	--		P
TRICELLARIA SP.	P	--	--		P
BOWERBANKIA GRACILIS	P	--	--		P
CHORDATA				4	
CIONA INTESTINALIS	--	2	2		4
AMAROUCIUM SP.	--	--	P		P
GRAND TOTALS 61	7502	1291	2176	10969	10969

RCH-A
Survey 2

STATION RCH-A

SURVEY NO. 2

TAXA	SAMPLE NO. 1	SAMPLE NO. 2	SAMPLE NO. 3	NUMBER OF GROUP	SPECIMENS TAXA
PROTOZOA				1	
FORAMINIFERA-UNIDENTIFIED SPP.	--	--	1		1
CNIDARIA				2	
CAMPANULARIA SP.	P	P	--		P
DIADUMENE SP.	1	--	1		2
NEMATODA				462	
NEMATODA-UNIDENTIFIED SPP.	122	249	91		462
ANNELIDA-OLIGOCHAETA				2166	
OLIGOCHAETA-UNIDENTIFIED SPP.	792	972	402		2166
ANNELIDA-POLYCHAETA				1375	
PSEUDOPOLYDORA PAUCIBRANCHIATA	9	31	17		57
POLYDORA LIGNI	57	163	242		462
SPHAEROSYLLIS SP.	6	111	29		146
EXOGONE LOUREI	77	240	272		589
HETEROMASTUS FILIFORMIS	40	10	31		81
STREBLOSPIO BENEDICTI	--	1	2		3
ETEONE LONGA CALIFORNICA	--	1	1		2
ETEONE LIGHTI	--	1	--		1
POLYCIRRUS SP.	--	2	2		4
COSSURA PYGODACTYLATA	--	15	4		19
ASYCHIS SP.	--	3	--		3
PSEUDOPOLYDORA KEMPI CALIFORNICA	--	1	--		1
GLYCINDE SP.	--	--	1		1
PYGOSPIO SP.	--	--	1		1
MARPHYSA SANGUINEA	2	3	--		5
ARTHROPODA				5642	
GRANDIDIERELLA JAPONICA	2	19	10		31
COROPHIUM SP., CF INSIDIOSUM	1	--	--		1
AMPELISCA MILLERI	291	2172	3531		5994
ACARINA-UNIDENTIFIED SPP.	173	12	--		185

STATION RCH-A SURVEY NO. 2 (CONT.)

TAXA	SAMPLE NO. 1	2	3	NUMBER OF GROUP	SPECIMENS TAXA
SARSIELLA SP.	4	--	--		4
COPEPODA-UNIDENTIFIED SPP.	3	33	--		36
SARSIELLA ZOSTERICOLA	--	90	93		183
SYNIDOTEA SP.	--	1	--		1
LEPTOCHELIA DUBIA	--	2	1		3
COROPHIUM SP.	--	--	4		4
MOLLUSCA				165	
MUSCULUS SENHOUSIA	21	49	73		143
TAPES JAPONICA	--	10	10		20
MYA ARENARIA	--	1	--		1
MACOMA BALTHICA - JUVENILE	--	--	1		1
ECTOPROCTA				P	
ELECTRA ARCTICA	P	--	--		P
CHORDATA				1	
CIONA INTESTINALIS	--	--	1		1
GRAND TOTALS 36	1601	4192	4821	13614	10614

STATION RCH-B

SURVEY NO. 2

TAXA	SAMPLE NO. 1	2	3	NUMBER OF GROUP	SPECIMENS TAXA
PROTOZOA				44	
FORAMINIFERA-UNIDENTIFIED SPP.	18	26	--		44
CNIDARIA				P	
CAMPANULARIA SP.	P	--	--		P
NEMERTEA				17	
NEMERTEA-UNIDENTIFIED SPP.	8	9	--		17
NEMATODA				261	
NEMATODA-UNIDENTIFIED SPP.	110	97	54		261
ANNELIDA-OLIGOCHAETA				699	
OLIGOCHAETA-UNIDENTIFIED SPP.	399	215	85		699
ANNELIDA-POLYCHAETA				3585	
STREBLOSPIO BENEDICTI	1261	1016	578		2855
PSEUDOPOLYDORA PAUCIBRANCHIATA	18	15	5		38
PSEUDOPOLYDORA KEMPI CALIFORNICA	7	37	4		48
EXOGONE LOUREI	158	91	44		293
SPHAEROSYLLIS SP.	54	21	8		83
COSSURA PYGODACTYLATA	72	76	56		204
HETEROMASTUS FILIFORMIS	10	9	18		37
CAPITELLA CAPITATA	2	17	--		19
THARYX PARVUS	1	--	--		1
CIRRIFORMIA SPIRABRANCHA	1	--	--		1
POLYDORA LIGNI	4	--	--		4
SCHISTOMERINGOS LONGICORNIS	1	--	1		2
ARTHROPODA				2583	
AMPELISCA MILLERI	1117	602	535		2254
ARACHNIDA-UNIDENTIFIED SPP.	1	--	--		1
COPEPODA-UNIDENTIFIED SPP.	33	14	8		55
PYCNOGONIDA-UNIDENTIFIED SPP.	--	1	--		1

STATION RCH-B SURVEY NO. 2 (CONT.)

TAXA		SAMPLE NO. 1	2	3	NUMBER OF GROUP	SPECIMENS TAXA
GRANDIDIERELLA JAPONICA		1	--	1		2
SARSIELLA ZOSTERICOLA		127	99	44		270
MOLLUSCA					47	
MUSCULUS SENHOUSIA		17	6	6		29
MACOMA NASUTA - JUVENILE		2	--	--		2
TAPES JAPONICA		2	--	2		4
ODOSTOMIA (EVALEA) SP. A		1	--	--		1
GEMMA GEMMA		--	4	1		5
NASSARIUS OBSOLETUS		--	1	--		1
ODOSTOMIA (EVALEA) FRANCISCANA		--	1	--		1
ODOSTOMIA (EVALEA) TENUISCULPTA		--	1	--		1
MACOMA NASUTA		--	--	2		2
MYA ARENARIA		--	--	1		1
GRAND TOTALS	33	3425	2358	1453	7236	7236

STATION MIS-A

SURVEY NO. 3

TAXA		SAMPLE NO. 1	2	3	NUMBER OF GROUP	SPECIMENS TAXA
NEMATODA					23	
NEMATODA-UNIDENTIFIED SPP.		3	6	14		23
ANNELIDA-OLIGOCHAETA					11	
OLIGOCHAETA-UNIDENTIFIED SPP.		1	4	6		11
ANNELIDA-POLYCHAETA					1	
STREBLOSPIO BENEDICTI		--	1	--		1
ARTHROPODA					18	
COPEPODA-UNIDENTIFIED SPP.		--	1	15		16
AMPELISCA MILLERI		--	1	--		1
INSECTA-UNIDENTIFIED LARVA		--	--	1		1
ECTOPROCTA					P	
MEMBRANIPORA PERFRAGILIS		P	P	P		P
GRAND TOTALS	7	4	13	36	53	53

STATION MIS-B

SURVEY NO. 3

TAXA		SAMPLE NO. 1	2	3	NUMBER OF GROUP	SPECIMENS TAXA
NEMATODA					184	
NEMATODA-UNIDENTIFIED SPP.		30	100	54		184
ANNELIDA-OLIGOCHAETA					11714	
OLIGOCHAETA-UNIDENTIFIED SPP.		3752	4185	3777		11714
ANNELIDA-POLYCHAETA					124	
STREBLOSPIO BENEDICTI		9	46	64		119
NEANTHES SUCCINEA		3	2	--		5
SIPUNCULA					1	
SIPUNCULA-UNIDENTIFIED SPP.		1	--	--		1
ARTHROPODA					91	
COPEPODA-UNIDENTIFIED SPP.		1	52	38		91
MOLLUSCA					36	
MACOMA BALTHICA		4	11	5		20
MUSCULUS SENHOUSIA		--	1	--		1
MYA ARENARIA		--	6	7		13
ODOSTOMIA (MENESTHO) FETELLA		--	--	1		1
PELECYPODA-UNIDENTIFIED JUVENILE		1	--	--		1
ECTOPROCTA					P	
MEMBRANIPORA PERFRAGILIS		P	P	P		P
GRAND TOTALS	12	3801	4403	3946	12150	12150

CS-A
Survey 3

STATION CS-A

SURVEY NO. 3

TAXA	SAMPLE NO. 1	2	3	NUMBER OF GROUP	SPECIMENS TAXA
NEMATODA				37	
NEMATODA-UNIDENTIFIED SPP.	26	1	10		37
ANNELIDA-OLIGOCHAETA				169	
OLIGOCHAETA-UNIDENTIFIED SPP.	72	49	48		169
ANNELIDA-POLYCHAETA				6	
GLYCINDE SP.	1	1	1		3
STREBLOSPIO BENEDICTI	1	--	--		1
HETEROMASTUS FILIFORMIS	--	--	1		1
NEANTHES SUCCINEA	--	--	1		1
ARTHROPODA				21	
PARAPHOXUS MILLERI	1	7	2		10
DECAPODA-UNIDENTIFIED LARVA	1	--	--		1
HALACARIDAE-UNIDENTIFIED SPP.	1	--	--		1
COPEPODA-UNIDENTIFIED SPP.	--	1	1		2
BALANUS SP.	--	1	--		1
BALANUS CARIOSUS	--	--	6		6
MOLLUSCA				67	
MYA ARENARIA	1	62	--		63
MYTILUS EDULIS	--	2	--		2
MUSCULUS SENHOUSIA	--	1	--		1
NASSARIUS OBSOLETUS	--	1	--		1
ECTOPROCTA				P	
CONOPEUM RETICULUM	P	--	--		P
MEMBRANIPORA PERFRAGILIS	--	P	P		P
GRAND TOTALS 18	104	126	70	300	300

CS-B
Survey 3

STATION CS-B

SURVEY NO. 3

TAXA	SAMPLE NO. 1	2	3	NUMBER OF GROUP	SPECIMENS TAXA
CNIDARIA				P	
CNIDARIA-UNIDENTIFIED SPP.	P	P	P		P
NEMATODA				157	
NEMATODA-UNIDENTIFIED SPP.	69	71	17		157
ANNELIDA-OLIGOCHAETA				1392	
OLIGOCHAETA-UNIDENTIFIED SPP.	640	415	337		1392
ANNELIDA-POLYCHAETA				82	
STREBLOSPIO BENEDICTI	26	11	32		69
GLYCINDE SP.	1	2	3		6
ETEONE LIGHTI	--	1	2		3
HETEROMASTUS FILIFORMIS	--	--	1		1
THARYX SP.	--	--	1		1
NEANTHES SUCCINEA	--	2	--		2
ARTHROPODA				42	
BALANUS CARIOSUS	41	--	--		41
PYCNOGONIDA-UNIDENTIFIED SPP.	--	--	1		1
MOLLUSCA				122	
MYA ARENARIA	9	35	6		50
MACOMA BALTHICA	16	16	15		47
MUSCULUS SENHOUSIA	--	2	--		2
TAPES JAPONICA	--	1	--		1
ODOSTOMIA (MENESTHO) FETELLA	--	11	--		11
ODOSTOMIA (EVALEA) TENUISCULPTA	--	8	--		8
ODOSTOMIA (EVALEA) FRANCISCANA	--	1	--		1
ODOSTOMIA (EVALEA) SP., CF DELICIOSA	--	2	--		2
GRAND TOTALS 19	802	578	415	1795	1795

ALC
Survey 3

STATION ALC

SURVEY NO. 3

TAXA	SAMPLE NO. 1	3	4	NUMBER OF GROUP	SPECIMENS TAXA
PORIFERA				P	
DEMOSPONGIAE-UNIDENTIFIED SPP.	--	--	P		P
NEMATODA				2	
NEMATODA-UNIDENTIFIED SPP.	--	2	--		2
ANNELIDA-OLIGOCHAETA				1	
OLIGOCHAETA-UNIDENTIFIED SPP.	--	1	--		1
ARTHROPODA				2	
DIASTYLOPSIS SP.	1	--	--		1
ISCHYROCERUS SP.	--	1	--		1
MOLLUSCA				2	
MACOMA NASUTA	1	--	--		1
ADULA DIEGENSIS	--	1	--		1
ECTOPROCTA				P	
ELECTRA ARCTICA	P	--	--		P
CONOPEUM RETICULUM	--	--	P		P
GRAND TOTALS 9	2	5	P	7	7

OIH
Survey 3

STATION OIH

SURVEY NO. 3

TAXA	SAMPLE NO. 1	2	3	NUMBER OF GROUP	SPECIMENS TAXA
PROTOZOA				2	
FORAMINIFERA-UNIDENTIFIED SPP.	2	--	--		2
PORIFERA				P	
DEMOSPONGIAE-UNIDENTIFIED SPP.	--	--	P		P
CNIDARIA				6	
STYLATULA ELONGATA	1	--	4		5
CAMPANULARIA SP.	P	--	--		P
HYDROZOA-UNIDENTIFIED SPP.	--	P	--		P
HALIPLANELLA SP.	--	--	1		1
NEMERTEA				44	
NEMERTEA-UNIDENTIFIED SPP.	16	6	22		44
NEMATODA				2230	
NEMATODA-UNIDENTIFIED SPP.	1083	240	907		2230
ANNELIDA-OLIGOCHAETA				13084	
OLIGOCHAETA-UNIDENTIFIED SPP.	5541	3284	4259		13084
ANNELIDA-POLYCHAETA				14991	
HAPLOSCOLOPLOS PUGETTENSIS	10	4	--		14
PHOLOE MINUTA	3	5	6		14
ARMANDIA BREVIS	1	1	--		2
ETEONE LIGHTI	3	4	1		8
ETEONE LONGA CALIFORNICA	3	5	2		10
DISOMA MULTISETOSUM - JUVENILE	1	--	--		1
PSEUDOPOLYDORA PAUCIBRANCHIATA	2	2	2		6
STREBLOSPIO BENEDICTI	5792	3951	4381		14124
ASYCHIS SP.	2	1	2		5
SPHAEROSYLLIS SP.	92	85	38		215
EXOGONE LOUREI	104	218	145		467
CAPITELLA CAPITATA	5	1	1		7

STATION OIH SURVEY NO. 3 (CONT.)

TAXA	SAMPLE NO. 1	SAMPLE NO. 2	SAMPLE NO. 3	NUMBER OF GROUP	SPECIMENS TAXA
GYPTIS BREVIPALPA	1	--	1		2
NEPHTYS CAECOIDES	2	3	--		5
NEPHTYS CORNUTA FRANCISCANA	1	9	5		15
GLYCINDE SP.	6	6	5		17
PECTINARIA CALIFORNIENSIS	5	8	10		23
COSSURA PYGODACTYLATA	--	1	--		1
NEANTHES SP.	--	1	--		1
CAPITELLA SP.	--	10	--		10
POLYDORA LIGNI	--	1	--		1
DISOMA MULTISETOSUM	--	1	--		1
NEPHTYS PARVA	--	--	2		2
THARYX PARVUS	--	--	1		1
ETEONE SP., CF DILATAE	--	--	1		1
HAPLOSCOLOPLOS PUGETTENSIS - JUVENILE	--	--	9		9
MEDIOMASTUS CALIFORNIENSIS	--	--	1		1
GLYCERA AMERICANA	--	--	1		1
ETEONE DILATAE	2	--	--		2
SCOLELEPSIS SQUAMATA	2	2	--		4
MESIONELLA MCCULLOCHAE	1	--	3		4
SPIOPHANES SP.	--	--	1		1
SCHISTOMERINGOS LONGICORNIS	8	1	4		13
POLYDORA CAULLERYI	--	1	--		1
TEREBELLIDAE-UNIDENTIFIED JUVENILE	--	--	1		1
PRIONOSPIO CIRRIFERA	--	--	1		1
SIPUNCULA				29	
SIPUNCULA-UNIDENTIFIED SPP.	--	29	--		29
ARTHROPODA				824	
COPEPODA-UNIDENTIFIED SPP.	5	2	1		8
ARACHNIDA-UNIDENTIFIED SPP.	1	--	--		1
PYCNOGONIDA-UNIDENTIFIED SPP.	1	--	--		1
PINNIXA FRANCISCANA	3	2	3		8
SARSIELLA ZOSTERICOLA	206	123	129		458
CUMELLA VULGARIS	151	132	48		331
AMPELISCA MILLERI	4	--	2		6
LEPTOCHELIA DUBIA	2	1	1		4
EUDORELLA SP.	4	1	--		5
? COPEPODA-UNIDENTIFIED SPP.	--	1	--		1
INSECTA-UNIDENTIFIED SPP.	1	--	--		1
MOLLUSCA				3036	
GEMMA GEMMA	892	1200	821		2913

STATION OIH: SURVEY NO. 3 (CONT.)

TAXA	SAMPLE NO. 1	SAMPLE NO. 2	SAMPLE NO. 3	NUMBER OF GROUP	SPECIMENS TAXA
MACOMA NASUTA	47	40	12		99
MYTILUS EDULIS	8	--	--		8
MACOMA INQUINATA	--	1	--		1
MYSELLA FERRUGINOSA	--	1	2		3
MUSCULUS SENHOUSIA	--	--	4		4
TRANSENNELLA TANTILLA	--	--	8		8
ECTOPROCTA				P	
BUGULA NERITINA	P	P	--		P
ALCYONIDIUM PARASITICUM	P	--	--		P
CONOPEUM RETICULUM	--	P	--		P
ECHINODERMATA				65	
HOLOTHUROIDEA-UNIDENTIFIED SPP.	41	--	24		65
GRAND TOTALS 68	14055	9384	10872	34311	34311

STATION HP

SURVEY NO. 3

TAXA	SAMPLE NO. 1	2	3	NUMBER OF GROUP	SPECIMENS TAXA
CNIDARIA				19	
HALIPLANELLA SP.	18	--	1		19
CAMPANULARIA SP.	P	P	P		P
NEMERTEA				32	
NEMERTEA-UNIDENTIFIED SPP.	14	4	14		32
NEMATODA				21	
NEMATODA-UNIDENTIFIED SPP.	8	6	7		21
ANNELIDA-OLIGOCHAETA				29	
OLIGOCHAETA-UNIDENTIFIED SPP.	17	9	3		29
ANNELIDA-POLYCHAETA				658	
POLYDORA SOCIALIS	2	1	1		4
PHOLOE MINUTA	1	1	--		2
ETEONE SP., CF LONGA CALIFORNICA	2	--	--		2
POLYDORA LIGNI	2	--	--		2
CAPITELLA CAPITATA	2	--	--		2
STREBLOSPIO BENEDICTI	5	6	3		14
ARMANDIA BREVIS	2	1	2		5
THARYX SP.	7	6	11		24
NEPHTYS CORNUTA FRANCISCANA	5	6	4		15
GLYCINDE SP.	1	1	--		2
EXOGONE LOUREI	78	65	57		200
SPHAEROSYLLIS SP.	5	6	3		14
MEDIOMASTUS CALIFORNIENSIS	111	90	75		276
ASYCHIS SP.	10	27	15		52
CIRRATULUS CIRRATUS	--	5	--		5
ETEONE LONGA CALIFORNICA	--	1	--		1
COSSURA PYGODACTYLATA	--	--	1		1
GYPTIS BREVIPALPA	--	--	1		1
GLYCERA SP.	--	--	1		1
GLYCERA OXYCEPHALA	--	1	--		1
OPHIODROMUS PUGETTENSIS	--	1	--		1
NOTOMASTUS (CLISTOMASTUS) TENUIS	5	--	--		5

STATION HP SURVEY NO. 3 (CONT.)

TAXA		SAMPLE NO. 1	2	3	NUMBER OF GROUP	SPECIMENS TAXA
SPIOPHANES MISSIONENSIS		1	2	--		3
PILARGIS SP.		1	--	--		1
POLYDORA SOCIALIS - JUVENILE		--	1	--		1
DISOMA MULTISETOSUM		2	--	--		2
SCHISTOMERINGOS LONGICORNIS		2	--	3		5
POLYDORA CAULLERYI		4	5	5		14
POLYDORA CAULLERYI - JUVENILE		1	--	--		1
STHENELANELLA UNIFORMIS		--	--	1		1
SIPUNCULA					2	
SIPUNCULA-UNIDENTIFIED SPP.		--	2	--		2
ARTHROPODA					65	
AMPELISCA MILLERI		10	17	10		37
COROPHIUM SP.		2	1	2		5
LEPTOCHELIA DUBIA		5	--	2		7
PYROMAIA TUBERCULATA		1	--	--		1
SARSIELLA ZOSTERICOLA		4	5	3		12
UPOGEBIA PUGETTENSIS		--	1	--		1
PHOTIS SP.		--	1	--		1
PHOTIS SP., CF BREVIPES		--	--	1		1
MOLLUSCA					15	
MACOMA NASUTA		2	2	--		4
GEMMA GEMMA		3	--	1		4
MYSELLA FERRUGINOSA		1	--	--		1
MUSCULUS SENHOUSIA		--	1	--		1
MACOMA BALTHICA		--	--	5		5
GRAND TOTALS	49	334	275	232	341	941

SB-A
Survey 3

STATION SB-A

SURVEY NO. 3

TAXA	SAMPLE NO. 1	SAMPLE NO. 2	SAMPLE NO. 3	NUMBER OF GROUP	SPECIMENS TAXA
PROTOZOA				2	
FORAMINIFERA-UNIDENTIFIED SPP.	2	--	--		2
CNIDARIA				55	
CAMPANULARIA SP.	P	P	P		P
HALIPLANELLA SP.	7	29	16		52
DIADUMENE SP.	--	--	3		3
NEMERTEA				4	
NEMERTEA-UNIDENTIFIED SPP.	--	3	1		4
NEMATODA				449	
NEMATODA-UNIDENTIFIED SPP.	40	63	345		448
ANNELIDA-OLIGOCHAETA				1147	
OLIGOCHAETA-UNIDENTIFIED SPP.	230	347	570		1147
ANNELIDA-POLYCHAETA				2568	
PSEUDOPOLYDORA KEMPI CALIFORNICA	16	--	1		17
COSSURA PYGODACTYLATA	6	1	1		8
ASYCHIS SP.	14	--	2		16
STREBLOSPIO BENEDICTI	18	7	6		31
CAPITELLIDAE-UNIDENTIFIED SPP.	4	--	--		4
ETEONE LIGHTI	1	--	--		1
POLYNOIDAE-UNIDENTIFIED JUVENILE	3	--	3		6
HARMOTHOE IMBRICATA	4	5	1		10
SPHAEROSYLLIS SP.	163	102	221		486
EXOGONE LOUREI	504	422	634		1560
POLYDORA LIGNI	11	6	3		20
HETEROMASTUS FILIFORMIS	64	110	61		235
PSEUDOPOLYDORA PAUCIBRANCHIATA	1	7	--		8
HARMOTHOE SP. - JUVENILE	--	8	--		8
MARPHYSA SANGUINEA	--	2	1		3
CAPITELLA CAPITATA	--	3	--		3
ODONTOSYLLIS PARVA	2	9	9		20

SB-A
Survey 3

STATION SB-A SURVEY NO. 3 (CONT.)

TAXA	SAMPLE NO. 1	2	3	NUMBER OF GROUP	SPECIMENS TAXA
POLYDORA CAULLERYI	74	37	1		112
SCHISTOMERINGOS LONGICORNIS	7	4	9		20
ARTHROPODA				2693	
COPEPODA-UNIDENTIFIED SPP.	38	31	314		383
PYCNOGONIDA-UNIDENTIFIED SPP.	2	1	1		4
SARSIELLA ZOSTERICOLA	29	63	22		114
ACARINA-UNIDENTIFIED SPP.	143	279	1699		2121
LEPTOCHELIA DUBIA	1	2	2		5
GRANDIDIERELLA JAPONICA	1	--	--		1
AMPELISCA MILLERI	35	15	5		55
SYNIDOTEA LATICAUDA	1	--	--		1
COROPHIUM ACHERUSICUM	--	3	--		3
PARAPLEUSTES SP.	--	1	--		1
COROPHIUM SP., CF ACHERUSICUM	--	--	5		5
MOLLUSCA				961	
TAPES JAPONICA	18	81	50		149
MUSCULUS SENHOUSIA	34	420	325		779
CREPIDULA PLANA	1	--	--		1
ISELICA OVOIDEA	3	12	4		19
BUSYCON CANALICULATUM	1	--	--		1
MYA ARENARIA	--	1	--		1
EPITONIUM TINCTUM	--	5	--		5
UROSALPINX CINEREA	--	2	--		2
GEMMA GEMMA	--	--	1		1
MACOMA BALTHICA	--	--	1		1
CREPIDULA CONVEXA	--	--	1		1
? MUSCULUS SENHOUSIA - JUVENILE	--	1	--		1
ECTOPROCTA				P	
ALCYONIDIUM POLYOUM	P	--	--		P
ELECTRA CRUSTULENTA	--	P	--		P
CONOPEUM RETICULUM	--	--	P		P
CHORDATA				22	
FISH LARVAE	3	--	--		3
CIONA INTESTINALIS	--	7	12		19
GRAND TOTALS 54	1461	2089	4330	7900	7900

STATION SB-B

SURVEY NO. 3

TAXA	SAMPLE NO. 1	2	3	NUMBER OF SPECIMENS GROUP	TAXA
CNIDARIA				P	
CAMPANULARIA SP.	P	P	P		P
NEMATODA				3	
NEMATODA-UNIDENTIFIED SPP.	2	1	--		3
ANNELIDA-OLIGOCHAETA				910	
OLIGOCHAETA-UNIDENTIFIED SPP.	129	193	583		910
ANNELIDA-POLYCHAETA				1298	
ETEONE LIGHTI	1	--	2		3
ETEONE LONGA CALIFORNICA	2	4	1		7
STREBLOSPIO BENEDICTI	45	35	21		101
POLYDORA LIGNI	52	97	89		238
PSEUDOPOLYDORA KEMPI CALIFORNICA	26	46	3		75
HARMOTHOE IMBRICATA	1	--	1		2
COSSURA PYGODACTYLATA	4	3	7		14
HAPLOSCOLOPLOS PUGETTENSIS	1	3	--		4
CIRRATULUS CIRRATUS	9	10	25		44
THARYX PARVUS	1	--	--		1
SPHAEROSYLLIS SP.	11	10	20		41
EXOGONE LOUREI	113	163	125		401
ASYCHIS SP.	9	20	16		45
MARPHYSA SANGUINEA	1	1	--		2
HETEROMASTUS FILIFORMIS	64	92	125		281
ETEONE SP., CF LONGA CALIFORNICA	--	1	--		1
CAPITELLA CAPITATA	--	--	2		2
GLYCINDE SP.	--	--	1		1
POLYDORA CAULLERYI	3	15	--		18
SCHISTOMERINGOS LONGICORNIS	4	4	5		13
HARMOTHOE SP. - JUVENILE	--	2	--		2
THARYX SP.	--	--	1		1
CHAETOZONE SP.	--	--	1		1
ARTHROPODA				164	
AMPELISCA MILLERI	29	23	21		73

SB-B
Survey 3

STATION SB-B SURVEY NO. 3 (CONT.)

TAXA		SAMPLE NO. 1	2	3	NUMBER OF GROUP	SPECIMENS TAXA
SARSIELLA ZOSTERICOLA		24	25	18		67
PYCNOGONIDA-UNIDENTIFIED SPP.		2	1	--		3
LEPTOCHELIA DUBIA		1	6	3		10
PARAPLEUSTES SP., CF PUGETTENSIS		6	1	1		8
GRANDIDIERELLA JAPONICA		1	--	--		1
COPEPODA-UNIDENTIFIED SPP.		--	2	--		2
MOLLUSCA					80	
MYA ARENARIA		1	--	--		1
MACOMA SP. - JUVENILE		2	--	--		2
MUSCULUS SENHOUSIA		10	2	2		14
TAPES JAPONICA		25	14	20		59
CREPIDULA PLANA		1	--	--		1
CREPIDULA CONVEXA		1	1	--		2
MACOMA INQUINATA		--	--	1		1
ECTOPROCTA					P	
MEMBRANIPORA SP.		--	P	--		P
AETEA ANGUINA		--	P	--		P
ALCYONIDIUM POLYOUM		--	P	--		P
CHORDATA					1	
FISH LARVAE		--	1	--		1
GRAND TOTALS	44	581	776	1099	2456	2456

STATION RCH-A

SURVEY NO. 3

TAXA	SAMPLE NO. 1	2	3	NUMBER OF GROUP	SPECIMENS TAXA
PROTOZOA				7	
FORAMINIFERA-UNIDENTIFIED SPP.	1	6	--		7
CNIDARIA				2	
CAMPANULARIA SP.	P	P	P		P
DIADUMENE SP.	--	2	--		2
NEMERTEA				1	
NEMERTEA-UNIDENTIFIED SPP.	--	1	--		1
NEMATODA				617	
NEMATODA-UNIDENTIFIED SPP.	247	344	26		617
ANNELIDA-OLIGOCHAETA				1261	
OLIGOCHAETA-UNIDENTIFIED SPP.	547	670	44		1261
ANNELIDA-POLYCHAETA				2106	
HETEROMASTUS FILIFORMIS	17	31	8		56
GLYCINDE SP.	2	--	--		2
ETEONE LONGA CALIFORNICA	3	--	1		4
POLYNOIDAE-UNIDENTIFIED JUVENILE	2	--	--		2
STREBLOSPIO BENEDICTI	176	122	15		313
THARYX SP.	1	4	--		5
PSEUDOPOLYDORA KEMPI CALIFORNICA	12	21	14		47
POLYDORA LIGNI	50	73	52		175
PSEUDOPOLYDORA PAUCIBRANCHIATA	1	--	--		1
ASYCHIS SP.	12	14	14		40
COSSURA PYGODACTYLATA	104	99	7		210
SPHAEROSYLLIS SP.	198	143	4		345
EXOGONE LOUREI	439	397	46		882
HARMOTHOE IMBRICATA	--	2	3		5
HAPLOSCOLOPLOS PUGETTENSIS	--	1	1		2
CAPITELLA CAPITATA	--	1	1		2
TEREBELLIDAE-UNIDENTIFIED JUVENILE	--	4	--		4
ETEONE LIGHTI	--	--	1		1

RCH-A
Survey 3

STATION RCH-A SURVEY NO. 3 (CONT.)

TAXA		SAMPLE NO. 1	2	3	NUMBER OF GROUP	SPECIMENS TAXA
POLYCIRRUS SP. - JUVENILE		--	--	1		1
ETEONE LIGHTI - JUVENILE		--	1	--		1
SCHISTOMERINGOS LONGICORNIS		--	2	--		2
HARMOTHOE SP. - JUVENILE		--	3	--		3
CAPITELLA SP.		--	2	--		2
AUTOLYTUS SP.		--	--	1		1
ARTHROPODA					2966	
COPEPODA-UNIDENTIFIED SPP.		29	42	1		72
PYCNOGONIDA-UNIDENTIFIED SPP.		2	--	--		2
ACARINA-UNIDENTIFIED SPP.		411	156	2		569
SARSIELLA ZOSTERICOLA		97	110	22		229
SYNIDOTEA LATICAUDA		1	--	1		2
LEPTOCHELIA DUBIA		1	--	--		1
AMPELISCA MILLERI		774	525	676		1975
COROPHIUM SP.		1	--	--		1
COROPHIUM ACHERUSICUM		--	9	4		13
GRANDIDIERELLA JAPONICA		--	1	1		2
MOLLUSCA					61	
TAPES JAPONICA		4	7	16		27
GEMMA GEMMA		1	--	--		1
MUSCULUS SENHOUSIA		12	2	14		28
MACOMA NASUTA		2	1	2		5
ECTOPROCTA					P	
ECTOPROCTA-UNIDENTIFIED SPP.		--	P	--		P
GRAND TOTALS	45	3147	2796	978	6921	6921

STATION RCH-B

SURVEY NO. 3

TAXA	SAMPLE NO. 1	SAMPLE NO. 2	SAMPLE NO. 3	NUMBER OF GROUP	SPECIMENS TAXA
PROTOZOA				98	
FORAMINIFERA-UNIDENTIFIED SPP.	--	84	14		98
CNIDARIA				P	
CAMPANULARIA SP.	--	P	--		P
NEMERTEA				11	
NEMERTEA-UNIDENTIFIED SPP.	5	1	5		11
NEMATODA				202	
NEMATODA-UNIDENTIFIED SPP.	85	87	30		202
ANNELIDA-OLIGOCHAETA				1429	
OLIGOCHAETA-UNIDENTIFIED SPP.	514	604	311		1429
ANNELIDA-POLYCHAETA				4348	
EXOGONE LOUREI	40	3	15		58
STREBLOSPIO BENEDICTI	1781	887	1276		3944
COSSURA PYGODACTYLATA	140	43	46		229
POLYDORA LIGNI	1	--	--		1
CAPITELLA CAPITATA	5	4	--		9
CAPITELLIDAE-UNIDENTIFIED JUVENILE	2	--	--		2
SPHAEROSYLLIS SP.	2	--	2		4
PSEUDOPOLYDORA KEMPI CALIFORNICA	29	6	23		58
ETEONE LIGHTI	1	--	--		1
HETEROMASTUS FILIFORMIS	15	8	14		37
NEPHTYS CAECOIDES	--	--	1		1
NEANTHES SUCCINEA	--	--	2		2
SCHISTOMERINGOS LONGICORNIS	2	--	--		2
ARTHROPODA				2392	
COPEPODA-UNIDENTIFIED SPP.	2	--	--		2
SARSIELLA ZOSTERICOLA	58	37	51		146
PYCNOGONIDA-UNIDENTIFIED SPP.	1	--	--		1

RCH-B
Survey 3

STATION RCH-B SURVEY NO. 3 (CONT.)

TAXA		SAMPLE NO. 1	2	3	NUMBER OF GROUP	SPECIMENS TAXA
COROPHIUM SP., CF ACHERUSICUM		2	--	--		2
AMPELISCA MILLERI		1343	15	883		2241
MOLLUSCA					45	
MUSCULUS SENHOUSIA		12	6	10		28
TAPES JAPONICA		2	--	2		4
MACOMA BALTHICA		4	--	--		4
ODOSTOMIA (EVALEA) VALDEZI		3	--	--		3
GEMMA GEMMA		1	3	--		4
ODOSTOMIA (EVALEA) SP.		--	1	--		1
MACOMA NASUTA		--	--	1		1
CHORDATA					1	
CIONA INTESTINALIS		1	--	--		1
GRAND TOTALS	31	4051	1789	2686	8526	8526

STATION MIS-A

SURVEY NO. 4

TAXA	SAMPLE NO. 1	2	3	NUMBER OF GROUP	SPECIMENS TAXA
PROTOZOA				P	
VORTICELLA SP.	--	P	--		P
CNIDARIA				P	
HYDROZOA-UNIDENTIFIED SPP.	P	P	P		P
NEMATODA				93	
NEMATODA-UNIDENTIFIED SPP.	7	69	17		93
ANNELIDA-OLIGOCHAETA				197	
OLIGOCHAETA-UNIDENTIFIED SPP.	33	132	32		197
ARTHROPODA				25	
COPEPODA-UNIDENTIFIED SPP.	5	6	12		23
AMPELISCA MILLERI	--	1	--		1
ARACHNIDA-UNIDENTIFIED SPP.	--	--	1		1
MOLLUSCA				18	
MACOMA BALTHICA	4	6	7		17
ODOSTOMIA (EVALEA) FRANCISCANA	--	1	--		1
ECTOPROCTA				P	
MEMBRANIPORA PERFRAGILIS	--	P	P		P
GRAND TOTALS 10	49	215	69	333	333

STATION MIS-B

SURVEY NO. 4

TAXA		SAMPLE NO. 1	2	3	NUMBER OF GROUP	SPECIMENS TAXA
CNIDARIA					P	
HYDROZOA-UNIDENTIFIED SPP.		P	--	--		P
NEMATODA					135	
NEMATODA-UNIDENTIFIED SPP.		52	37	46		135
ANNELIDA-OLIGOCHAETA					11925	
OLIGOCHAETA-UNIDENTIFIED SPP.		3812	4423	3690		11925
ANNELIDA-POLYCHAETA					146	
ETEONE LIGHTI		1	1	2		4
NEANTHES SUCCINEA		3	3	1		7
STREBLOSPIO BENEDICTI		28	42	65		135
ARTHROPODA					49	
COPEPODA-UNIDENTIFIED SPP.		21	15	12		48
INSECTA-UNIDENTIFIED SPP.		--	--	1		1
MOLLUSCA					52	
MACOMA BALTHICA		15	13	18		46
MYA ARENARIA		--	--	6		6
GRAND TOTALS	10	3932	4534	3841	12307	12307

STATION CS-A

SURVEY NO. 4

TAXA	SAMPLE NO. 1	SAMPLE NO. 2	SAMPLE NO. 3	NUMBER OF GROUP	SPECIMENS TAXA
CNIDARIA				P	
CAMPANULARIA SP.	--	P	--		P
NEMATODA				1267	
NEMATODA-UNIDENTIFIED SPP.	54	942	271		1267
ANNELIDA-OLIGOCHAETA				4114	
OLIGOCHAETA-UNIDENTIFIED SPP.	1223	1779	1112		4114
ANNELIDA-POLYCHAETA				214	
STREBLOSPIO BENEDICTI	103	42	36		181
ETEONE LIGHTI	8	8	2		18
HETEROMASTUS FILIFORMIS	2	1	1		4
THARYX SP.	--	2	--		2
NEANTHES SUCCINEA	2	1	--		3
GLYCINDE SP.	1	2	1		4
THARYX PARVUS	1	--	--		1
PSEUDOPOLYDORA KEMPI CALIFORNICA	1	--	--		1
ARTHROPODA				3	
SYNIDOTEA LATICAUDA	1	--	--		1
INSECTA-UNIDENTIFIED SPP.	--	--	2		2
MOLLUSCA				100	
MACOMA BALTHICA	24	35	36		95
MYA ARENARIA	5	--	--		5
ECTOPROCTA				P	
MEMBRANIPORA VILLOSA	--	P	--		P
MEMBRANIPORA PERFRAGILIS	--	P	P		P
ELECTRA ARCTICA	--	--	P		P
CONOPEUM RETICULUM	--	--	P		P
GRAND TOTALS 19	1425	2812	1461	5698	5698

CS-B
Survey 4

STATION CS-B

SURVEY NO. 4

TAXA	SAMPLE NO. 1	2	3	NUMBER OF GROUP	SPECIMENS TAXA
PROTOZOA				2	
FORAMINIFERA-UNIDENTIFIED SPP.	--	2	--		2
CNIDARIA				P	
HYDROZOA-UNIDENTIFIED SPP.	P	--	--		P
NEMATODA				85	
NEMATODA-UNIDENTIFIED SPP.	3	68	14		85
ANNELIDA-OLIGOCHAETA				646	
OLIGOCHAETA-UNIDENTIFIED SPP.	180	327	139		646
ANNELIDA-POLYCHAETA				18	
STREBLOSPIO BENEDICTI	1	1	4		6
ETEONE LONGA CALIFORNICA	1	--	--		1
POLYDORA LIGNI - JUVENILE	--	4	--		4
ETEONE LIGHTI	--	3	3		6
GLYCINDE SP.	--	1	--		1
ARTHROPODA				10	
COPEPODA-UNIDENTIFIED SPP.	1	4	2		7
AMPELISCA MILLERI	--	2	--		2
MYSIDACEA-UNIDENTIFIED SPP.	--	--	1		1
MOLLUSCA				52	
MACOMA BALTHICA	8	13	11		32
TAPES JAPONICA	1	--	--		1
MYA ARENARIA	17	2	--		19
ECTOPROCTA				P	
MEMBRANIPORA VILLOSA	--	--	P		P
MEMBRANIPORA PERFRAGILIS	--	--	P		P

STATION CS-B SURVEY NO. 4 (CONT.)

TAXA		SAMPLE NO. 1	2	3	NUMBER OF GROUP	SPECIMENS TAXA
ENIGMATICA					1	
ENIGMATICA		--	1	--		1
GRAND TOTALS	18	212	428	174	814	814

ALC
Survey 4

STATION ALC

SURVEY NO. 4

TAXA	SAMPLE NO. 1	2	3	NUMBER OF GROUP	SPECIMENS TAXA
PROTOZOA				1	
FORAMINIFERA-UNIDENTIFIED SPP.	--	--	1		1
CNIDARIA				P	
HYDROZOA-UNIDENTIFIED SPP.	--	--	P		P
NEMERTEA				20	
NEMERTEA-UNIDENTIFIED SPP.	5	12	3		20
NEMATODA				56	
NEMATODA-UNIDENTIFIED SPP.	--	24	32		56
ANNELIDA-OLIGOCHAETA				17	
OLIGOCHAETA-UNIDENTIFIED SPP.	2	8	7		17
ANNELIDA-POLYCHAETA				1314	
GLYCERA TENUIS	9	12	8		29
SCOLELEPSIS SQUAMATA	1	--	--		1
ANAITIDES WILLIAMSI	1	--	--		1
STREPTOSYLLIS SP.	122	601	363		1086
MEDIOMASTUS CALIFORNIENSIS	--	1	--		1
MESIONURA SP.	--	115	74		189
NEPHTYS CALIFORNIENSIS	--	--	1		1
POLYDORA CAULLERYI - JUVENILE	--	--	2		2
SPIOPHANES BOMBYX	--	--	4		4
ARTHROPODA				8	
LAMPROPS SP., CF QUADRIPLICATA	1	--	1		2
AMPELISCA MILLERI	2	--	--		2
COROPHIUM ACHERUSICUM	--	1	1		2
PARAPHOXUS MILLERI	--	--	1		1
PHOTIS SP.	--	--	1		1

STATION ALC SURVEY NO. 4 (CONT.)

TAXA		SAMPLE NO. 1	2	3	NUMBER OF GROUP	SPECIMENS TAXA
MOLLUSCA					3	
ADULA DIEGENSIS		1	--	--		1
TELLINA MODESTA		1	1	--		2
ECTOPROCTA					P	
HIPPOTHOA HYALINA		P	--	P		P
CALLOPORA ARMATA		--	--	P		P
SCRUPOCELLARIA SP.		--	--	P		P
TEGELLA ARMIFERA		--	--	P		P
TRICELLARIA SP.		--	--	P		P
CRISIA MAXIMA		--	--	P		P
SCHIZOPORELLA SP.		--	--	P		P
GRAND TOTALS	28	145	775	499	1419	1419

ALC
Survey 4

OIH
Survey 4

STATION OIH

SURVEY NO. 4

TAXA	SAMPLE NO. 1	2	3	NUMBER OF GROUP	SPECIMENS TAXA
CNIDARIA					
STYLATULA ELONGATA	--	1	--	1	1
PLUMULARIA SP.	--	P	--		P
NEMERTEA					
NEMERTEA-UNIDENTIFIED SPP.	5	--	8	13	13
NEMATODA					
NEMATODA-UNIDENTIFIED SPP.	20	206	1366	1592	1592
ANNELIDA-OLIGOCHAETA					
OLIGOCHAETA-UNIDENTIFIED SPP.	378	585	1173	2136	2136
ANNELIDA-POLYCHAETA				1047	
NEPHTYS CORNUTA FRANCISCANA	2	--	4		6
PHOLOE MINUTA	3	--	3		6
DISOMA MULTISETOSUM	1	1	--		2
NEPHTYS CAECOIDES	3	4	2		9
ETEONE LIGHTI	21	14	26		61
GLYCINDE SP.	1	1	--		2
SCOLELEPSIS SQUAMATA	2	2	1		5
SCOLELEPSIS SQUAMATA - JUVENILE	3	--	--		3
CAPITELLA CAPITATA	3	1	3		7
STREBLOSPIO BENEDICTI	139	154	286		579
SCHISTOMERINGOS LONGICORNIS	3	1	4		P
SPHAEROSYLLIS SP.	4	3	8		15
EXOGONE LOUREI	64	53	208		325
POLYDORA LIGNI	--	--	3		3
COSSURA PYGODACTYLATA	--	1	2		3
PECTINARIA CALIFORNIENSIS	--	2	1		3
MEDIOMASTUS CALIFORNIENSIS	--	--	1		1
HARMOTHOE IMBRICATA	--	--	3		3
ETEONE LONGA CALIFORNICA	--	--	1		1
HETEROMASTUS FILIFORMIS	--	2	--		2
SPIOPHANES MISSIONENSIS	--	1	--		1
GYPTIS BREVIPALPA	--	1	--		1

STATION OIH SURVEY NO. 4 (CONT.)

TAXA	SAMPLE NO. 1	2	3	NUMBER OF GROUP	SPECIMENS TAXA
CIRRATULUS CIRRATUS	--	1	--		1
ARTHROPODA				132	
PINNIXA FRANCISCANA	1	--	1		2
PYCNOGONIDA-UNIDENTIFIED SPP.	1	--	--		1
SARSIELLA ZOSTERICOLA	11	3	4		18
EUDORELLA SP.	1	--	1		2
CUMELLA VULGARIS	45	11	9		65
COPEPODA-UNIDENTIFIED SPP.	1	8	10		19
AMPELISCA MILLERI	6	1	7		14
COROPHIUM ACHERUSICUM	6	--	4		10
CALLIANASSA CALIFORNIENSIS	--	--	1		1
MOLLUSCA				315	
MACOMA NASUTA	19	38	29		86
MACOMA INQUINATA	7	3	4		14
MYTILUS EDULIS	2	--	2		4
MUSCULUS SENHOUSIA	1	--	--		1
MYSELLA FERRUGINOSA	3	2	--		5
GEMMA GEMMA	120	35	49		204
TELLINA MODESTA	--	--	1		1
ECTOPROCTA				P	
CRYPTOSULA PALLASIANA	--	--	P		P
GRAND TOTALS 45	876	1135	3225	5236	5236

HP
Survey 4

STATION HP

SURVEY NO. 4

TAXA	SAMPLE NO. 1	2	3	NUMBER OF GROUP	SPECIMENS TAXA
PORIFERA				P	
PORIFERA-UNIDENTIFIED SPP.	---	---	P		P
CNIDARIA				20	
HALIPLANELLA SP.	3	1	16		20
CAMPANULARIA SP.	P	P	P		P
BIMERIA SP.	---	P	P		P
NEMERTEA				43	
NEMERTEA-UNIDENTIFIED SPP.	22	8	13		43
NEMATODA				51	
NEMATODA-UNIDENTIFIED SPP.	20	22	9		51
ANNELIDA-OLIGOCHAETA				41	
OLIGOCHAETA-UNIDENTIFIED SPP.	7	15	19		41
ANNELIDA-POLYCHAETA				1534	
NEPHTYS CORNUTA FRANCISCANA	20	43	30		93
GLYCINDE SP.	10	8	11		29
GLYCERA SP. - JUVENILE	3	---	2		5
STREBLOSPIO BENEDICTI	1	---	2		3
SCHISTOMERINGOS LONGICORNIS	3	2	1		6
CIRRATULUS CIRRATUS	12	15	14		41
HAPLOSCOLOPLOS PUGETTENSIS	1	---	---		1
THARYX PARVUS	6	---	15		21
GYPTIS BREVIPALPA	1	---	---		1
DISOMA MULTISETOSUM	3	1	2		6
ANAITIDES SP.	1	---	---		1
POLYDORA CAULLERYI	9	7	9		25
POLYDORA LIGNI - JUVENILE	5	---	---		5
POLYDORA SOCIALIS	1	1	---		2
EXOGONE LOUREI	208	245	303		756
SPHAEROSYLLIS SP.	7	7	6		20
ASYCHIS SP.	8	11	11		30

STATION HP SURVEY NO. 4 (CONT.)

TAXA	SAMPLE NO. 1	2	3	NUMBER OF GROUP	SPECIMENS TAXA
MEDIOMASTUS CALIFORNIENSIS	101	160	143		404
CAPITELLIDAE-UNIDENTIFIED JUVENILE	1	--	--		1
PALEANOTUS BELLIS	--	--	1		1
POLYDORA LIGNI	--	23	24		47
PHOLOE MINUTA	--	--	1		1
PRIONOSPIO SP.	--	--	1		1
ETEONE LONGA CALIFORNICA	--	1	1		2
CAPITELLA CAPITATA	--	2	1		3
NEAR AMPHIDUROS PACIFICUS	--	--	1		1
AUTOLYTUS SP.	--	2	3		5
TYPOSYLLIS SP.	--	--	1		1
ARMANDIA BREVIS	--	1	--		1
ETEONE SP., CF LONGA CALIFORNICA	--	2	--		2
GLYCERA SP.	--	3	--		3
THARYX SP.	--	9	--		9
COSSURA PYGODACTYLATA	--	3	--		3
SABELLIDAE-UNIDENTIFIED SPP.	--	1	--		1
SABELLARIA SP.	--	1	--		1
SPIOPHANES MISSIONENSIS	--	2	--		2
SIPUNCULA				3	
SIPUNCULA-UNIDENTIFIED SPP.	1	--	--		1
SIPUNCULUS SP.	--	--	2		2
ARTHROPODA				474	
SARSIELLA ZOSTERICOLA	22	19	19		60
EUDORELLA SP.	6	4	4		14
LEPTOCHELIA DUBIA	12	3	12		27
COROPHIUM ACHERUSICUM	66	92	114		272
AMPELISCA MILLERI	131	161	145		437
PROTOMEDEIA SP.	1	--	--		1
PARAPLEUSTES PUGETTENSIS	1	--	--		1
DECAPODA-UNIDENTIFIED SPP.	--	1	--		1
ACARINA-UNIDENTIFIED SPP.	--	33	9		42
COPEPODA-UNIDENTIFIED SPP.	--	1	3		4
CUMELLA VULGARIS	--	2	--		2
PARAPLEUSTES SP.	--	4	--		4
ANOMURA-UNIDENTIFIED LARVA	--	1	--		1
RITHROPANOPEUS HARRISII	--	1	--		1
PYROMAIA TUBERCULATA	--	--	1		1
CANCER JORDANI	--	--	1		1
PARAPLEUSTES SP., CF PUGETTENSIS	--	--	2		2
CAPRELLIDEA-UNIDENTIFIED SPP.	--	--	2		2
PYCNOGONIDA-UNIDENTIFIED SPP.	--	--	1		1

HP
Survey 4

STATION HP   SURVEY NO. 4 (CONT.)

TAXA		SAMPLE NO. 1	SAMPLE NO. 2	SAMPLE NO. 3	NUMBER OF GROUP	SPECIMENS TAXA
MOLLUSCA					29	
OSTREA LURIDA		1	--	--		1
MUSCULUS SENHOUSIA		2	--	--		2
MYTILUS EDULIS		1	8	2		11
TRANSENNELLA TANTILLA		1	2	--		3
TAPES JAPONICA		1	--	--		1
MYSELLA FERRUGINOSA		1	--	--		1
MACOMA BALTHICA		2	--	--		2
MODIOLUS SP.		--	1	--		1
HIATELLA ARCTICA		--	1	--		1
MACOMA INQUINATA		--	--	3		3
MYA ARENARIA		--	--	1		1
GEMMA GEMMA		--	--	2		2
ECTOPROCTA					P	
HIPPOTHOA HYALINA		--	--	P		P
SMITTOIDEA PROLIFICA		--	P	--		P
ENTOPROCTA						
BARENTSIA SP.		P	--	P		P
ECHINODERMATA					2	
OPHIONEREIS SP.		--	1	--		1
HOLOTHUROIDEA-UNIDENTIFIED SPP.		--	--	1		1
PHORONIDA					2	
PHORONIDA-UNIDENTIFIED SPP.		1	--	--		1
PHORONIS SP.		--	1	--		1
ENIGMATICA					2	
ENIGMATICA		--	2	--		2
GRAND TOTALS	84	703	934	964	2601	2601

STATION SB-A

SURVEY NO. 4

TAXA	SAMPLE NO. 1	2	3	NUMBER OF GROUP	SPECIMENS TAXA
CNIDARIA				P	
SERTULARIA SP.	P	--	--		P
CAMPANULARIA SP.	P	P	--		P
NEMATODA				116	
NEMATODA-UNIDENTIFIED SPP.	69	30	17		116
ANNELIDA-OLIGOCHAETA				1293	
OLIGOCHAETA-UNIDENTIFIED SPP.	591	304	398		1293
ANNELIDA-POLYCHAETA				1057	
CAPITELLA CAPITATA	22	8	12		42
HETEROMASTUS FILIFORMIS	106	36	115		257
EXOGONE LOUREI	94	125	64		283
SCHISTOMERINGOS LONGICORNIS	2	1	2		5
STREBLOSPIO BENEDICTI	45	150	5		200
ETEONE LONGA CALIFORNICA	24	38	3		65
CIRRATULUS CIRRATUS	--	2	1		3
HARMOTHOE IMBRICATA	3	4	5		12
SPHAEROSYLLIS SP.	5	15	2		22
ETEONE LIGHTI	8	8	10		26
PSEUDOPOLYDORA KEMPI CALIFORNICA	5	10	1		16
POLYDORA CAULLERYI	12	10	1		23
POLYDORA LIGNI	14	33	11		58
MARPHYSA SANGUINEA	--	--	2		2
GLYCINDE SP.	4	7	7		18
HAPLOSCOLOPLOS PUGETTENSIS	3	--	--		3
THARYX SP.	2	--	--		2
ASYCHIS SP.	5	12	--		17
COSSURA PYGODACTYLATA	--	2	--		2
CIRRIFORMIA SPIRABRANCHA	--	1	--		1
ARTHROPODA				1341	
COPEPODA-UNIDENTIFIED SPP.	2	10	--		12
SARSIELLA ZOSTERICOLA	4	37	2		43
SYNIDOTEA LATICAUDA	3	--	--		3

SB-A
Survey 4

STATION SB-A SURVEY NO. 4 (CONT.)

TAXA		SAMPLE NO. 1	2	3	NUMBER OF GROUP	SPECIMENS TAXA
LEPTOCHELIA DUBIA		1	1	1		3
AMPELISCA MILLERI		66	684	24		774
COROPHIUM ACHERUSICUM		109	297	49		455
GRANDIDIERELLA JAPONICA		5	4	7		16
PYCNOGONIDA-UNIDENTIFIED SPP.		--	2	--		2
ACARINA-UNIDENTIFIED SPP.		--	17	--		17
CUMELLA VULGARIS		--	1	--		1
PARAPLEUSTES PUGETTENSIS		--	14	--		14
COROPHIUM SP.		--	--	1		1
MOLLUSCA					828	
TAPES JAPONICA		362	27	375		764
MUSCULUS SENHOUSIA		8	2	11		21
MYA ARENARIA		2	3	1		6
NUDIBRANCHIA-UNIDENTIFIED SPP.		4	--	2		6
ISELICA OVOIDEA		7	--	16		23
CREPIDULA CONVEXA		1	3	1		5
GEMMA GEMMA		--	2	1		3
ECTOPROCTA					P	
ALCYONIDIUM POLYOUM		P	--	--		P
ELECTRA CRUSTULENTA		P	P	--		P
CONOPEUM COMMENSALE		P	--	--		P
ALCYONIDIUM PARASITICUM		--	--	P		P
MEMBRANIPORA VILLOSA		--	--	P		P
SCRUPOCELLARIA SP.		--	P	--		P
CHORDATA					85	
CIONA INTESTINALIS		6	79	--		85
ENIGMATICA					1	
ENIGMATICA		1	--	--		1
GRAND TOTALS	51	1595	1979	1147	4721	4721

SB-B
Survey 4

STATION SB-B

SURVEY NO. 4

TAXA	SAMPLE NO. 1	SAMPLE NO. 2	SAMPLE NO. 3	NUMBER OF GROUP	SPECIMENS TAXA
PROTOZOA				3	
FORAMINIFERA-UNIDENTIFIED SPP.	2	1	--		3
PORIFERA				P	
DEMOSPONGIAE-UNIDENTIFIED SPP.	P	--	--		P
CNIDARIA				P	
CAMPANULARIA SP.	P	P	P		P
HYDROZOA-UNIDENTIFIED SPP.	P	--	--		P
NEMATODA				36	
NEMATODA-UNIDENTIFIED SPP.	17	16	3		36
ANNELIDA-OLIGOCHAETA				680	
OLIGOCHAETA-UNIDENTIFIED SPP.	334	136	210		680
ANNELIDA-POLYCHAETA				3224	
ASYCHIS SP.	26	16	27		69
HETEROMASTUS FILIFORMIS	44	81	46		171
HARMOTHOE IMBRICATA	6	9	7		22
GLYCINDE SP.	4	11	7		22
ETEONE LIGHTI	10	5	9		24
ETEONE LONGA CALIFORNICA	57	54	45		156
SCHISTOMERINGOS LONGICORNIS	5	3	4		12
CAPITELLA CAPITATA	33	26	32		91
MEDIOMASTUS CALIFORNIENSIS	1	--	--		1
COSSURA PYGODACTYLATA	10	1	5		16
CIRRATULUS CIRRATUS	21	11	9		41
POLYDORA CAULLERYI	18	33	11		62
POLYDORA LIGNI	40	54	47		141
PSEUDOPOLYDORA KEMPI CALIFORNICA	20	40	51		111
DISOMA MULTISETOSUM	1	--	--		1
STREBLOSPIO BENEDICTI	569	405	560		1534
EXOGONE LOUREI	267	222	156		645
SPHAEROSYLLIS SP.	32	40	26		98

SB-B
Survey 4

STATION SB-B SURVEY NO. 4 (CONT.)

TAXA		SAMPLE NO. 1	2	3	NUMBER OF GROUP	SPECIMENS TAXA
EIEONE SP., CF LIGHTI		--	3	--		3
HAPLOSCOLOPLOS PUGETTENSIS		--	3	--		3
LYSIDICE NINETTA		--	1	--		1
ARTHROPODA					6072	
SARSIELLA ZOSTERICOLA		48	51	40		139
PYCNOGONIDA-UNIDENTIFIED SPP.		4	16	13		33
LEPTOCHELIA DUBIA		1	1	--		2
COROPHIUM ACHERUSICUM		245	373	269		887
AMPELISCA MILLERI		711	2351	1845		4907
PARAPLEUSTES PUGETTENSIS		30	36	--		66
GRANDIDIERELLA JAPONICA		2	5	7		14
COPEPODA-UNIDENTIFIED SPP.		--	3	--		3
CUMELLA VULGARIS		--	2	2		4
ISOPODA-UNIDENTIFIED SPP.		--	3	--		3
? PYCNOGONIDA-UNIDENTIFIED JUVENILE		--	3	--		3
ACARINA-UNIDENTIFIED SPP.		--	8	--		8
SYNIDOTEA LATICAUDA		--	3	--		3
MOLLUSCA					84	
MACOMA BALTHICA		1	--	1		2
TAPES JAPONICA		16	20	3		39
GEMMA GEMMA		1	--	2		3
MUSCULUS SENHOUSIA		9	6	9		24
MYA ARENARIA		2	3	6		11
MYTILUS EDULIS		--	1	3		4
MACOMA NASUTA		--	--	1		1
ECTOPROCTA					P	
MEMBRANIPORA VILLOSA		--	P	P		P
CHORDATA					25	
CIONA INTESTINALIS		11	1	13		25
GRAND TOTALS	49	2598	4057	3469	10124	10124

RCH-A
Survey 4

STATION RCH-A

SURVEY NO. 4

TAXA	SAMPLE NO. 1	SAMPLE NO. 2	SAMPLE NO. 3	NUMBER OF SPECIMENS GROUP	NUMBER OF SPECIMENS TAXA
PROTOZOA				11	
FORAMINIFERA-UNIDENTIFIED SPP.	6	--	5		11
PORIFERA				P	
HEXACTINELLIDA-UNIDENTIFIED SPP.	--	P	--		P
PORIFERA-UNIDENTIFIED SPP.	--	P	--		P
CNIDARIA				1	
HYDROZOA-UNIDENTIFIED SPP.	--	P	--		P
CNIDARIA-UNIDENTIFIED SPP.	--	--	1		1
SERTULARIA SP.	--	--	P		P
CAMPANULARIA SP.	--	--	P		P
NEMATODA				1322	
NEMATODA-UNIDENTIFIED SPP.	418	762	142		1322
ANNELIDA-OLIGOCHAETA				9881	
OLIGOCHAETA-UNIDENTIFIED SPP.	2718	3180	3983		9881
ANNELIDA-POLYCHAETA				4507	
SCHISTOMERINGOS LONGICORNIS	3	4	9		16
COSSURA PYGODACTYLATA	9	44	49		102
SPHAEROSYLLIS SP.	109	39	109		257
GLYCINDE SP.	7	3	12		22
HARMOTHOE IMBRICATA	11	6	12		29
STREBLOSPIO BENEDICTI	641	1054	444		2139
HETEROMASTUS FILIFORMIS	73	76	94		243
ASYCHIS SP.	1	3	6		10
CAPITELLA CAPITATA	7	14	16		37
POLYDORA LIGNI	20	42	26		88
PSEUDOPOLYDORA KEMPI CALIFORNICA	51	119	50		220
EXOGONE LOUREI	300	255	475		1030
MARPHYSA SANGUINEA	17	5	5		27
ETEONE LIGHTI	38	33	39		110
ETEONE LONGA CALIFORNICA	41	63	56		170

RCH-A
Survey 4

STATION RCH-A SURVEY NO. 4 (CONT.)

TAXA	SAMPLE NO. 1	2	3	NUMBER OF GROUP	SPECIMENS TAXA
? POLYCIRRUS SP.	--	2	--		2
HAPLOSCOLOPLOS PUGETTENSIS	1	--	--		1
POLYCIRRUS SP.	--	--	1		1
STREPTOSYLLIS SP.	--	1	--		1
CAPITELLA SP. - JUVENILE	--	1	--		1
SYLLIDAE-UNIDENTIFIED SPP.	--	--	1		1
ARTHROPODA				5825	
COROPHIUM ACHERUSICUM	85	61	75		221
CUMELLA VULGARIS	13	2	5		20
ACARINA-UNIDENTIFIED SPP.	145	155	557		857
GRANDIDIERELLA JAPONICA	10	5	5		20
SYNIDOTEA SP.	--	--	1		1
PARAPLEUSTES SP., CF PUGETTENSIS	--	2	4		6
COPEPODA-UNIDENTIFIED SPP.	34	34	114		182
SYNIDOTEA LATICAUDA	1	--	--		1
COROPHIUM SP., CF ACHERUSICUM	75	--	--		75
AMPELISCA MILLERI	2562	977	626		4165
PARAPLEUSTES PUGETTENSIS	4	--	--		4
SARSIELLA ZOSTERICOLA	146	33	85		264
SYNIDOTEA SP. - JUVENILE	5	--	--		5
INSECTA-UNIDENTIFIED SPP.	--	2	--		2
BALANUS IMPROVISUS - JUVENILE	--	--	1		1
HEMIGRAPSUS OREGONENSIS	--	--	1		1
MOLLUSCA				365	
MACOMA NASUTA	--	3	--		3
TAPES JAPONICA	80	80	180		340
GEMMA GEMMA	2	1	4		7
MYTILUS EDULIS	1	1	--		2
MUSCULUS SENHOUSIA	3	1	6		10
NASSARIUS OBSOLETUS	--	--	1		1
MYA ARENARIA	2	--	--		2
ECTOPROCTA				P	
ELECTRA ARCTICA	P	P	P		P
MEMBRANIPORA VILLOSA	--	--	P		P
MEMBRANIPORELLA SP.	--	--	P		P
CHORDATA				2	
CIONA INTESTINALIS	--	--	2		2
GRAND TOTALS 57	7639	7063	7212	21914	21914

RCH-B
Survey 4

STATION RCH-B

SURVEY NO. 4

TAXA	SAMPLE NO. 1	2	3	NUMBER OF GROUP	SPECIMENS TAXA
PROTOZOA				520	
FORAMINIFERA-UNIDENTIFIED SPP.	143	134	243		520
CNIDARIA				P	
SYNCORYNE SP.	--	P	--		P
HYDROZOA-UNIDENTIFIED SPP.	--	P	P		P
NEMERTEA				8	
NEMERTEA-UNIDENTIFIED SPP.	--	7	1		8
NEMATODA				1584	
NEMATODA-UNIDENTIFIED SPP.	147	206	1231		1584
ANNELIDA-OLIGOCHAETA				2921	
OLIGOCHAETA-UNIDENTIFIED SPP.	444	1211	1266		2921
ANNELIDA-POLYCHAETA				2542	
PSEUDOPOLYDORA KEMPI CALIFORNICA	13	4	7		24
POLYDORA LIGNI	1	--	8		9
GLYCINDE SP.	2	4	3		9
HETEROMASTUS FILIFORMIS	7	19	55		81
CAPITELLA CAPITATA	3	4	14		21
STREBLOSPIO BENEDICTI	130	344	808		1282
COSSURA PYGODACTYLATA	11	48	17		76
ETEONE LONGA CALIFORNICA	2	--	3		5
ETEONE LIGHTI	41	68	135		244
SPHAEROSYLLIS SP.	42	104	192		338
EXOGONE LOUREI	71	147	221		439
SCHISTOMERINGOS LONGICORNIS	--	1	1		2
ASYCHIS SP.	--	1	3		4
HARMOTHOE SP. - JUVENILE	--	--	1		1
PSEUDOPOLYDORA PAUCIBRANCHIATA	--	--	1		1
SPIONIDAE-UNIDENTIFIED JUVENILE	--	--	1		1
MEDIOMASTUS CALIFORNIENSIS	1	--	2		3
CAPITELLIDAE-UNIDENTIFIED SPP.	--	--	2		2

STATION RCH-B SURVEY NO. 4 (CONT.)

TAXA		SAMPLE NO. 1	2	3	NUMBER OF GROUP	SPECIMENS TAXA
ARTHROPODA					6879	
SARSIELLA ZOSTERICOLA		40	114	206		360
PYCNOGONIDA-UNIDENTIFIED SPP.		1	--	--		1
COPEPODA-UNIDENTIFIED SPP.		47	172	458		677
CUMELLA VULGARIS		6	17	41		64
COROPHIUM ACHERUSICUM		19	43	183		245
GRANDIDIERELLA JAPONICA		8	14	50		72
AMPELISCA MILLERI		1098	2164	2176		5438
ACARINA-UNIDENTIFIED SPP.		--	3	14		17
SYNIDOTEA HARFORDI		--	--	1		1
OSTRACODA-UNIDENTIFIED SPP.		--	--	4		4
MOLLUSCA					128	
MUSCULUS SENHOUSIA		9	21	31		61
GEMMA GEMMA		4	6	6		16
MYA ARENARIA		12	9	18		39
TAPES JAPONICA		--	1	--		1
MACOMA NASUTA		--	5	1		6
SILIQUA PATULA		--	1	--		1
ODOSTOMIA (EVALEA) VALDEZI		--	1	--		1
MYTILUS EDULIS		--	--	1		1
NASSARIUS OBSOLETUS		--	--	1		1
ODOSTOMIA (EVALEA) FRANCISCANA		--	--	1		1
GRAND TOTALS	44	2302	4873	7407	14582	14582

APPENDIX B

PHYSICAL AND CHEMICAL CHARACTERISTICS OF WATER

Survey P

PRELIMINARY SURVEY

	SAMPLE NO.	TEMPERATURE (CENTIGRADE)	SALINITY (PARTS/1000)	DISSOLVED OXYGEN (MILLIGRAMS/LITER)	TURBIDITY (NU)	TOTAL SULFIDES (MICROGRAMS/LITER)	PH	DEPTH (FEET)
MIS-A	1	12.9	4.3	8.6	450	10.0	7.7	36
	2	12.7	4.0	8.5	65	4.2	7.8	
MIS-B	1	12.0	3.4	9.0	130	6.1	7.7	36
	2	12.5	3.2	8.9	65	8.6	7.8	
CS-A	1	13.2	12.4	7.7	240	2.6	7.9	48
	2	13.1	5.2	8.2	85	7.3	7.9	
CS-B	1	13.5	7.6	8.0	>500	7.6	7.8	46
	2	13.0	6.8	8.4	>500	15.0	7.8	
ALC	1	11.5	28.5	7.4	11	2.1	8.0	90-150
DIH	1	14.2	23.0	7.3	2	.7	7.7	38
	2	12.4	21.0	7.1	3	2.4	7.9	
HP	1	12.0	24.0	7.7	5	2.7	7.9	58
	2	11.4	23.2	7.1	2	2.3	7.9	
SB-A	1	13.0	16.8	8.9	14	2.8	7.8	40
	2	12.0	17.8	8.6	11	3.2	7.9	
SB-B	1	12.4	17.0	8.6	10	3.3	7.7	36
	2	12.8	16.0	9.5	9	4.4	7.8	
RCH-A	1	12.9	14.0	8.9	11	4.9	7.9	47
	2	13.0	15.2	9.2	17	6.3	7.9	
RCH-B	1	13.1	17.8	8.6	11	3.7	7.8	36
	2	12.6	17.5	8.7	11	2.2	7.9	

Survey 1

SURVEY NO. 1

STATION	SAMPLE NO.	TEMPERATURE (CENTIGRADE)	SALINITY (PARTS/1000)	DISSOLVED OXYGEN (MILLIGRAMS/LITER)	TURBIDITY (NU)	TOTAL SULFIDES (MICROGRAMS/LITER)	PH	DEPTH (FEET)
MIS-A	1	20.0	10.0	8.2	100	2.1	7.4	30
	2	20.0	10.0	8.1	120	3.0	7.3	
MIS-B	1	19.9	23.5	7.2	130	3.0	7.5	25
	2	19.8	23.5	7.3	85	2.5	7.6	
CS-A	1	19.0	21.0	7.3	21	.5	7.7	48
	2	19.0	21.0	7.4	15	.2	7.7	
CS-B	1	19.0	22.0	7.3	10	.4	7.5	42
	2	19.0	22.0	7.5	10	.4	7.4	
ALC	1	15.7	30.0	7.7	5	.2	7.6	67
	2	15.6	30.5	7.7	5	0.0	7.6	
OIH	1	17.9	29.0	6.9	6	.6	7.5	30
	2	17.8	29.0	6.9	5	.5	7.5	
HP	1	18.3	30.0	7.3	8	0.0	7.4	50
	2	18.3	30.0	6.9	6	.8	7.6	
SB-A	1	19.0	29.5	6.9	2	2.8	7.5	42
	2	19.0	29.5	6.8	2	3.2	7.5	
SB-B	1	19.8	30.0	6.5	1	1.4	7.5	36
	2	19.6	30.0	6.6	2	1.7	7.5	
RCH-A	1	19.2	29.5	6.8	2	1.9	7.6	24
	2	19.2	29.5	6.7	1	3.5	7.6	
RCH-B	1	19.8	29.0	6.8	5	4.2	7.5	24
	2	19.8	29.0	6.6	5	2.5	7.6	

SURVEY NO. 2

STATION	SAMPLE NO.	TEMPERATURE (CENTIGRADE)	SALINITY (PARTS/1000)	DISSOLVED OXYGEN (MILLIGRAMS/LITER)	TURBIDITY (NU)	TOTAL SULFIDES (MICROGRAMS/LITER)	PH	DEPTH (FEET)
MIS-A	1	9.8	4.0	9.6	190	4.0	7.5	32
	2	10.0	4.0	9.7	110	3.5	7.5	
MIS-B	1	10.0	3.0	9.9	65	2.5	7.5	21
	2	10.0	3.0	9.8	95	4.3	7.4	
CS-A	1	10.0	7.0	9.3	130	1.9	7.5	50
	2	10.0	7.0	9.5	150	2.8	7.5	
CS-B	1	10.0	6.5	9.6	110	1.9	7.5	40
	2	10.0	6.0	10.0	120	2.6	7.5	
ALC	1	11.0	24.5	8.6	24	5.5	7.3	60
	2	11.0	24.0	8.6	23	4.4	7.4	
OIH	1	11.0	22.0	7.8	24	4.1	7.4	30
	2	11.0	22.0	7.9	24	2.1	7.6	
HP	1	11.0	22.0	7.7	7	.6	7.7	45
	2	11.0	22.0	8.4	12	--	7.7	
SB-A	1	12.0	20.0	8.5	7	1.5	7.7	44
	2	12.0	22.0	8.4	7	2.7	7.8	
SB-B	1	11.0	20.0	9.3	2	1.1	6.9	30
	2	10.9	22.0	8.8	1	1.3	7.5	
RCH-A	1	12.0	22.0	8.1	7	3.4	7.8	34
	2	12.0	22.0	8.3	6	1.5	7.7	
RCH-B	1	12.0	22.0	8.1	7	3.5	7.7	30
	2	12.0	22.0	8.2	7	4.9	7.7	

SURVEY NO. 3

STATION	SAMPLE NO.	TEMPERATURE (CENTIGRADE)	SALINITY (PARTS/1000)	DISSOLVED OXYGEN (MILLIGRAMS/LITER)	TURBIDITY (NU)	TOTAL SULFIDES (MICROGRAMS/LITER)	PH	DEPTH (FEET)
MIS-A	1	11.0	4.0	6.7	37500	--	7.7	30
	2	11.0	4.0	7.5	10000	1.8	7.8	
MIS-B	1	11.0	2.0	10.2	500	0.0	7.6	20
	2	11.0	1.5	10.0	500	--	7.6	
CS-A	1	11.0	15.5	9.0	160	1.4	7.9	50
	2	11.0	15.0	9.2	130	.2	7.9	
CS-B	1	11.0	14.0	9.1	100	.6	7.9	42
	2	11.0	15.5	8.9	140	1.6	8.0	
ALC	1	10.0	28.0	8.3	5	.4	8.0	60
	2	10.0	27.5	8.3	10	.2	8.0	
OIH	1	11.0	22.0	8.0	18	0.0	8.0	31
	2	11.4	22.5	8.1	18	--	8.0	
HP	1	11.0	21.0	8.4	45	1.8	8.2	48
	2	11.0	20.5	8.4	45	.4	8.1	
SB-A	1	11.0	18.0	9.3	45	.3	8.0	40
	2	11.0	19.0	9.2	40	1.5	8.0	
SB-B	1	11.2	18.5	8.8	23	.5	7.8	34
	2	11.2	18.5	9.0	34	.5	7.9	
RCH-A	1	11.8	18.0	9.0	33	0.0	8.0	38
	2	11.8	19.0	9.8	33	0.0	7.9	
RCH-B	1	12.0	18.0	8.5	14	0.0	7.9	30
	2	11.8	18.0	8.9	21	0.0	7.9	

Survey 4

SURVEY NO. 4

STATION	SAMPLE NO.	TEMPERATURE (CENTIGRADE)	SALINITY (PARTS/1000)	DISSOLVED OXYGEN (MILLIGRAMS/LITER)	TURBIDITY (NJ)	TOTAL SULFIDES (MICROGRAMS/LITER)	PH	DEPTH (FEET)
MIS-A	1	17.5	7.5	8.4	85	0.0	7.8	30
	2	17.5	7.5	8.5	70	0.0	7.9	
MIS-B	1	17.5	6.0	8.7	60	1.1	7.8	20
	2	17.5	6.5	8.4	30	0.0	7.8	
CS-A	1	16.0	18.0	8.1	120	1.1	7.9	48
	2	16.5	17.0	8.4	150	1.3	7.9	
CS-B	1	17.0	18.0	8.3	390	1.4	7.8	40
	2	17.0	16.0	8.4	260	0.0	7.9	
ALC	1	12.6	29.5	7.9	11	0.0	7.8	58
	2	12.3	29.5	7.8	12	0.0	7.8	
OIH	1	15.7	26.5	7.9	35	0.0	7.9	34
	2	15.3	26.5	7.8	37	0.0	7.8	
HP	1	15.0	25.0	8.0	35	0.0	7.9	52
	2	14.8	26.0	8.1	35	0.0	7.9	
SB-A	1	18.8	[illegible]	7.5	11	0.0	7.9	41
	2	18.3	21.0	7.5	13	0.0	7.8	
SB-B	1	18.8	21.0	7.3	--	0.0	7.8	32
	2	18.7	21.5	7.5	10	0.0	7.9	
RCH-A	1	18.7	21.5	7.1	40	0.0	7.8	45
	2	18.5	21.5	7.1	40	0.0	7.9	
RCH-B	1	18.8	21.5	7.0	28	0.0	7.3	32
	2	18.8	21.5	7.3	17	0.0	7.9	

APPENDIX C

PHYSICAL AND CHEMICAL CHARACTERISTICS OF SEDIMENT

TEMPERATURE, SULFIDES, SALINITY, pH,
AND SAMPLE VOLUME

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey P

PRELIMINARY SURVEY

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)		PH
MIS-A	1	10.0	12.3	.4	--		7.0
	2	10.0	12.2	2.4	--		7.0
	3	10.0	12.5	3.1	--		7.0
	4	10.0	12.3	2.0	--		7.0
	5	10.1	12.5	2.3	--		7.0
	6	10.0	12.2	--	--		7.1
	7	10.0	12.2	--	--		7.0
	MEAN	10.0	12.3	2.0	--	MIN	7.0
	STD. DEV.	0.0	.1	1.0	--	MAX	7.1
MIS-B	1	10.3	12.0	78.4	--		7.3
	2	9.6	12.0	.3	--		7.2
	3	10.1	11.7	1.8	--		7.3
	4	10.2	11.5	0.0	--		7.3
	5	10.1	12.1	4.4	--		7.1
	6	10.2	11.7	--	--		7.2
	MEAN	10.1	11.8	17.0	--	MIN	7.1
	STD. DEV.	.2	.2	34.4	--	MAX	7.3

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey P

PRELIMINARY SURVEY (CONTINUED)

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)		PH
CS-A	1	10.5	12.5	136.0	--		7.2
	2	10.5	11.9	.8	--		7.1
	3	10.5	11.5	129.0	--		7.1
	4	10.6	11.9	180.0	--		7.1
	5	10.7	12.4	168.0	--		7.2
	6	10.7	11.6	--	--		7.1
	7	10.7	11.5	--	--		7.1
	MEAN	10.6	11.9	122.8	--	MIN	7.1
	STD. DEV.	.1	.4	71.4	--	MAX	7.2
CS-B	1	10.0	13.0	.8	--		7.3
	2	9.1	12.5	.2	--		7.3
	3	10.8	12.5	.3	--		7.3
	4	10.0	12.5	1.6	--		7.3
	5	8.4	12.0	1.2	--		7.3
	6	9.9	11.9	--	--		7.3
	7	10.0	11.8	--	--		7.3
	MEAN	9.7	12.3	.8	--	MIN	7.3
	STD. DEV.	.8	.4	.6	--	MAX	7.3

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey P

PRELIMINARY SURVEY (CONTINUED)

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)		PH
ALC	1	5.3	11.8	1.0	--		7.9
	2	6.4	11.8	136.0	--		7.2
	3	6.8	11.0	42.7	--		7.4
	MEAN	6.2	11.5	59.9	--	MIN	7.2
	STD. DEV.	.8	.5	69.1	--	MAX	7.9
OIH	1	7.0	11.9	283.0	--		7.2
	2	5.8	11.4	354.0	--		7.3
	3	6.1	11.3	236.0	--		7.2
	4	8.5	11.1	443.0	--		7.3
	5	7.0	11.2	892.0	--		7.2
	6	8.0	11.0	--	--		7.2
	7	9.2	11.2	--	--		7.2
	MEAN	7.4	11.3	441.6	--	MIN	7.2
	STD. DEV.	1.2	.3	263.6	--	MAX	7.3

PRELIMINARY SURVEY (CONTINUED)

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)		PH
HP	1	10.7	11.3	19.1	--		7.1
	2	10.3	11.5	22.4	--		7.0
	3	9.0	11.5	57.8	--		7.3
	4	10.2	11.1	39.7	--		7.4
	5	10.7	11.2	46.1	--		7.1
	6	10.7	11.2	--	--		7.1
	7	10.8	11.1	--	--		7.2
	MEAN	10.3	11.3	37.0	--	MIN	7.0
	STD. DEV.	.6	.2	16.3	--	MAX	7.4
SB-A	1	11.1	13.0	560.0	--		6.1
	2	11.0	12.3	370.0	--		7.5
	3	10.9	12.5	--	--		7.4
	4	11.2	12.5	125.0	--		6.4
	5	11.0	12.5	--	--		7.5
	6	11.0	12.5	410.0	--		7.5
	7	11.1	12.3	360.0	--		7.4
	MEAN	11.0	12.5	365.0	--	MIN	6.1
	STD. DEV.	.1	.2	156.3	--	MAX	7.5

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey P

PRELIMINARY SURVEY (CONTINUED)

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)		PH
SB-B	1	10.4	12.5	0.0	--		7.4
	2	10.3	12.3	320.0	--		7.2
	3	10.5	12.0	290.0	--		7.2
	4	10.3	12.0	290.0	--		7.3
	5	10.6	12.0	230.0	--		7.4
	6	10.5	12.0	260.0	--		7.2
	7	10.2	12.0	--	--		7.3
	MEAN	10.4	12.1	278.0	--	MIN	7.2
	STD. DEV.	.1	.2	34.2	--	MAX	7.4
RCH-A	1	10.2	14.0	300.0	--		7.4
	2	10.3	14.0	300.0	--		7.3
	3	10.2	14.0	260.0	--		7.3
	4	10.[illegible]	14.0	250.0	--		7.4
	5	10.6	13.5	--	--		7.3
	6	10.5	13.7	--	--		7.3
	7	10.5	13.5	196.0	--		7.3
	MEAN	10.4	13.8	261.2	--	MIN	7.3
	STD. DEV.	.2	.2	43.0	--	MAX	7.4

PRELIMINARY SURVEY (CONTINUED)

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)		PH
RCH-8	1	10.5	12.3	270.0	--		8.4
	2	10.8	12.3	116.0	--		7.4
	3	11.0	12.3	290.0	--		7.4
	4	11.0	12.0	188.0	--		7.5
	5	10.8	11.9	146.0	--		7.5
	6	10.0	11.9	103.0	--		7.4
	7	10.9	11.8	100.0	--		7.3
	MEAN	10.7	12.1	173.3	--	MIN	7.3
	STD. DEV.	.4	.2	79.1	--	MAX	8.4

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey 1

SURVEY NO. 1

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)		PH
MIS-A	1	9.5	19.0	23.0	--		6.7
	2	9.3	19.0	26.0	--		6.8
	3	9.7	19.0	40.0	--		6.8
	4	9.3	18.5	7.6	--		6.8
	5	9.1	18.5	5.4	--		6.8
	6	10.5	18.5	6.3	--		6.9
	MEAN	9.6	18.8	18.0	--	MIN	6.7
	STD. DEV.	.5	.3	14.0	--	MAX	6.9
MIS-B	1	10.5	19.0	190.0	--		7.0
	2	10.5	19.0	89.0	--		7.0
	3	10.8	19.0	210.0	--		7.0
	4	10.4	19.0	190.0	--		7.1
	5	10.5	19.0	180.0	--		7.1
	6	10.3	19.0	170.0	--		7.1
	MEAN	10.5	19.0	171.5	--	MIN	7.0
	STD. DEV.	.2	0.0	42.5	--	MAX	7.1

SURVEY NO. 1 (CONTINUED)

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)		PH
CS-A	1	10.3	18.5	370.0	--		6.4
	2	9.1	18.0	400.0	--		6.5
	3	9.1	18.0	170.0	--		6.7
	4	11.2	18.0	300.0	--		6.5
	5	12.0	18.0	320.0	--		6.4
	6	11.4	18.0	320.0	--		6.5
	MEAN	10.5	18.1	313.3	--	MIN	6.4
	STD. DEV.	1.2	.2	79.4	--	MAX	5.7
CS-B	1	10.2	18.5	73.0	--		6.7
	2	9.6	18.0	320.0	--		6.8
	3	10.0	18.5	140.0	--		6.8
	4	11.0	18.5	170.0	--		6.7
	5	10.0	18.5	290.0	--		6.6
	6	9.9	18.5	150.0	--		6.7
	MEAN	10.1	18.4	190.5	--	MIN	6.6
	STD. DEV.	.5	.2	95.0	--	MAX	6.8

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey 1

SURVEY NO. 1 (CONTINUED)

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)		PH
ALC	1	7.0	16.0	1.8	--		7.3
	2	7.3	16.0	2.0	--		7.1
	3	7.7	15.0	20.0	--		7.2
	4	7.3	16.0	10.0	--		6.9
	5	8.4	15.5	4.3	--		7.0
	6	7.3	16.0	.6	--		7.3
	MEAN	7.5	15.8	6.4	--	MIN	6.9
	STD. DEV.	.5	.4	7.4	--	MAX	7.3
OIH	1	11.1	17.5	380.0	--		7.2
	2	11.0	17.5	300.0	--		7.3
	3	11.0	17.0	650.0	--		7.2
	4	11.8	17.0	630.0	--		7.1
	5	11.3	17.0	580.0	--		7.2
	6	11.4	17.0	620.0	--		7.1
	MEAN	11.3	17.2	526.7	--	MIN	7.1
	STD. DEV.	.3	.3	148.5	--	MAX	7.3

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey 1

SURVEY NO. 1 (CONTINUED)

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)		PH
HP	1	11.3	18.0	30.0	--		6.9
	2	10.2	18.0	42.0	--		7.1
	3	10.6	18.0	30.0	--		7.0
	4	10.0	18.0	52.0	--		7.0
	5	10.0	18.0	76.0	--		7.0
	6	10.3	18.0	150.0	--		7.1
	MEAN	10.4	18.0	63.3	--	MIN	6.9
	STD. DEV.	.5	0.0	45.8	--	MAX	7.1
SB-A	1	11.3	19.0	150.0	--		6.7
	2	9.6	19.0	110.0	--		6.8
	3	11.4	19.0	180.0	--		7.0
	4	11.3	19.0	100.0	--		6.9
	5	11.6	19.0	110.0	--		7.0
	6	11.8	19.0	240.0	--		7.0
	MEAN	11.2	19.0	148.3	--	MIN	6.7
	STD. DEV.	.8	0.0	54.2	--	MAX	7.0

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey 1

SURVEY NO. 1 (CONTINUED)

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)		PH
SB-8	1	11.4	19.0	560.0	--		6.7
	2	11.2	19.0	510.0	--		6.5
	3	11.8	19.0	570.0	--		6.4
	4	11.8	19.0	460.0	--		7.0
	5	10.9	19.0	610.0	--		6.8
	6	11.0	19.0	560.0	--		7.0
	MEAN	11.3	19.0	545.0	--	MIN	6.4
	STD. DEV.	.4	0.0	52.4	--	MAX	7.0
RCH-A	1	10.9	19.0	140.0	--		6.9
	2	11.4	19.0	130.0	--		7.0
	3	10.7	19.0	120.0	--		7.0
	4	11.0	19.0	160.0	--		7.0
	5	11.2	19.0	190.0	--		7.1
	6	10.8	19.0	150.0	--		7.1
	MEAN	11.0	19.0	148.3	--	MIN	6.9
	STD. DEV.	.3	0.0	24.8	--	MAX	7.1

SURVEY NO. 1 (CONTINUED)

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)		PH
RCH-B	1	9.8	19.0	480.0	--		7.1
	2	11.0	20.0	440.0	--		7.0
	3	10.8	19.0	470.0	--		6.9
	4	11.1	19.0	730.0	--		7.0
	5	10.4	19.5	490.0	--		7.0
	6	10.9	19.5	600.0	--		6.9
	MEAN	10.7	19.3	535.0	--	MIN	6.9
	STD. DEV.	.5	.4	110.0	--	MAX	7.1

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey 2

SURVEY NO. 2

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)		PH
MIS-A	1	9.8	11.0	.5	--		7.1
	2	10.1	11.0	.7	--		7.1
	3	10.5	11.0	12.0	--		7.0
	4	10.3	10.9	.4	--		7.1
	5	10.3	11.0	1.2	--		7.0
	6	10.6	11.0	.3	--		7.0
	MEAN	10.3	11.0	2.5	--	MIN	7.0
	STD. DEV.	.3	0.0	4.7	--	MAX	7.1
MIS-B	1	11.0	10.2	69.0	--		7.2
	2	11.0	10.4	96.0	--		7.2
	3	11.2	10.4	86.0	--		7.3
	4	11.0	10.6	170.0	--		7.3
	5	11.4	10.3	35.0	--		7.3
	6	11.0	10.4	27.0	--		7.3
	MEAN	11.1	10.4	80.5	--	MIN	7.2
	STD. DEV.	.2	.1	51.7	--	MAX	7.3

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey 2

SURVEY NO. 2 (CONTINUED)

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)		PH
CS-A	1	10.4	10.7	150.0	--		6.8
	2	10.4	10.8	240.0	--		6.9
	3	10.7	10.9	180.0	--		6.9
	4	11.4	10.4	110.0	--		6.9
	5	10.5	10.7	14.0	--		6.9
	6	10.8	10.5	50.0	--		6.8
	MEAN	10.7	10.7	124.0	--	MIN	6.8
	STD. DEV.	.4	.2	83.7	--	MAX	6.9
CS-B	1	8.9	10.8	40.0	--		7.0
	2	10.4	10.9	240.0	--		7.0
	3	10.4	10.9	46.0	--		6.9
	4	10.7	10.6	57.0	--		7.0
	5	9.5	10.6	15.0	--		7.0
	6	10.1	11.0	41.0	--		7.0
	MEAN	10.0	10.8	73.2	--	MIN	6.9
	STD. DEV.	.7	.2	82.9	--	MAX	7.0

STATION HP SURVEY NO. 1 (CONT.)

TAXA	SAMPLE NO. 3	SAMPLE NO. 5	SAMPLE NO. 6	NUMBER OF GROUP	SPECIMENS TAXA
POLYDORA SOCIALIS	1	2	--		3
GLYCINDE SP.	--	6	1		7
SPIOPHANES FIMBRIATA	--	1	--		1
HETEROMASTUS FILIFORMIS	--	--	4		4
POLYDORA SP., CF SOCIALIS	--	--	1		1
SIPUNCULA				1	
SIPUNCULA-UNIDENTIFIED SPP.	--	1	--		1
ARTHROPODA				9103	
AMPELISCA MILLERI	1952	2382	4501		8835
LEPTOCHELIA DUBIA	77	97	65		239
SARSIELLA ZOSTERICOLA	--	1	4		5
COROPHIUM ACHERUSICUM	--	6	4		10
PYROMAIA TUBERCULATA	1	--	--		1
OSTRACODA-UNIDENTIFIED SPP.	4	--	--		4
COROPHIUM INSIDIOSUM	7	--	--		7
COROPHIUM SP.	2	--	--		2
MOLLUSCA				6	
PETRICOLA SP., CF CARDITOIDES	--	--	1		1
LYONSIA SP., CF CALIFORNICA	--	--	1		1
ADULA DIEGENSIS	1	--	--		1
MUSCULUS SENHOUSIA	1	--	--		1
TRANSENNELLA TANTILLA	--	1	--		1
MACOMA NASUTA	--	1	--		1
ECHINODERMATA				1	
HOLOTHUROIDEA-UNIDENTIFIED SPP.	--	--	1		1
PHORONIDA				1	
PHORONIS SP.	1	--	--		1
CHORDATA				8	
TUNICATA-UNIDENTIFIED SPP.	--	--	8		8
GRAND TOTALS 50	2791	2842	4881	10514	10514

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey 2

SURVEY NO. 2 (CONTINUED)

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)		PH
ALC	1	8.1	11.6	3.8	--		7.1
	2	8.1	11.2	7.6	--		7.0
	3	7.9	11.2	39.0	--		7.5
	4	8.3	11.4	24.0	--		7.4
	5	7.5	11.3	170.0	--		7.7
	6	7.0	11.7	180.0	--		7.7
	MEAN	7.8	11.4	70.7	--	MIN	7.0
	STD. DEV.	.5	.2	81.8	--	MAX	7.7
DIH	1	7.5	11.0	420.0	--		7.3
	2	7.5	11.0	440.0	--		7.3
	3	7.7	11.0	530.0	--		7.4
	4	9.4	11.0	630.0	--		7.4
	5	8.9	11.0	390.0	--		7.4
	6	9.1	11.0	520.0	--		7.4
	MEAN	8.3	11.0	488.3	--	MIN	7.3
	STD. DEV.	.9	0.0	88.9	--	MAX	7.4

SURVEY NO. 2 (CONTINUED)

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)		PH
HP	1	10.4	11.0	290.0	--		7.3
	2	9.6	11.0	100.0	--		7.4
	3	9.8	11.0	280.0	--		7.0
	4	9.6	11.0	230.0	--		7.3
	5	9.0	11.0	180.0	--		7.4
	6	9.9	11.0	170.0	--		7.3
	MEAN	9.7	11.0	208.0	--	MIN	7.0
	STD. DEV.	.5	0.0	72.5	--	MAX	7.4
SB-A	1	10.8	11.5	58.0	--		7.2
	2	10.1	11.2	130.0	--		7.1
	3	10.6	11.5	140.0	--		7.1
	4	9.9	11.2	160.0	--		7.2
	5	10.1	11.2	240.0	--		7.2
	6	11.0	11.5	180.0	--		7.3
	MEAN	10.4	11.3	151.3	--	MIN	7.1
	STD. DEV.	.4	.2	60.1	--	MAX	7.3

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey 2

SURVEY NO. 2 (CONTINUED)

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)		PH
SB-B	1	11.5	11.5	72.0	--		7.4
	2	11.7	11.8	100.0	--		7.5
	3	11.3	11.5	62.0	--		7.3
	4	10.4	11.8	70.0	--		7.4
	5	11.4	11.5	70.0	--		7.4
	6	10.9	11.5	90.0	--		7.4
	MEAN	11.2	11.6	77.3	--	MIN	7.3
	STD. DEV.	.5	.2	14.5	--	MAX	7.5
RCH-A	1	11.2	12.0	260.0	--		7.3
	2	10.9	11.8	180.0	--		7.2
	3	10.8	12.0	200.0	--		7.3
	4	10.9	11.8	240.0	--		7.3
	5	10.3	11.8	260.0	--		7.2
	6	11.0	11.5	280.0	--		7.3
	MEAN	10.9	11.8	236.7	--	MIN	7.2
	STD. DEV.	.2	.2	38.8	--	MAX	7.3

SURVEY NO. 2 (CONTINUED)

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)		PH
RCH-B	1	10.5	12.0	430.0	--		7.1
	2	10.5	12.0	1200.0	--		7.0
	3	10.7	12.0	620.0	--		7.1
	4	10.6	11.5	370.0	--		7.3
	5	10.7	12.0	760.0	--		7.0
	6	10.8	12.0	390.0	--		7.2
	MEAN	10.6	11.9	628.3	--	MIN	7.0
	STD. DEV.	.1	.2	318.5	--	MAX	7.3

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey 3

SURVEY NO. 3

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)		PH
MIS-A	1	10.8	12.0	24.0	10.5		7.0
	2	10.5	12.0	19.0	8.5		7.1
	3	10.0	11.5	5.8	8.5		7.1
	4	10.4	12.0	--	8.8		7.0
	MEAN	10.4	11.9	16.3	9.1	MIN	7.0
	STD. DEV.	.3	.3	[illegible].4	1.0	MAX	7.1
MIS-B	1	11.0	11.0	59.0	5.5		7.3
	2	9.4	11.0	64.0	5.0		7.2
	3	10.2	11.0	60.0	5.5		7.2
	4	10.8	11.0	--	5.8		7.2
	MEAN	10.3	11.0	61.0	5.4	MIN	7.2
	STD. DEV.	.7	0.0	2.6	.3	MAX	7.3
CS-A	1	7.0	11.0	3.4	12.2		7.3
	2	8.9	11.0	.9	12.5		7.0
	3	8.7	11.0	27.0	12.0		7.3
	4	9.3	11.0	--	12.8		7.4
	MEAN	9.5	11.0	10.4	12.4	MIN	7.0
	STD. DEV.	1.0	0.0	14.4	.4	MAX	7.4

SURVEY NO. 3 (CONTINUED)

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)		PH
CS-8	1	10.0	12.0	89.0	14.0		7.1
	2	10.5	12.0	220.0	13.5		7.1
	3	10.8	11.5	53.0	13.8		7.0
	4	10.5	11.5	--	13.5		7.2
	MEAN	10.4	11.8	120.7	13.7	MIN	7.0
	STD. DEV.	.3	.3	87.9	.2	MAX	7.2
ALC	1	9.5	10.2	77.0	23.0		7.4
	2	8.9	10.2	31.0	23.5		7.2
	3	9.8	10.2	120.0	23.5		7.1
	4	10.2	10.2	--	23.5		7.2
	MEAN	9.6	10.2	76.0	23.4	MIN	7.1
	STD. DEV.	.5	0.0	44.5	.3	MAX	7.4
OIH	1	8.7	11.5	600.0	24.2		7.7
	2	7.9	11.5	550.0	24.0		7.8
	3	8.0	11.5	560.0	23.8		7.7
	4	8.8	10.2	--	24.0		7.7
	MEAN	8.3	11.2	570.0	24.0	MIN	7.7
	STD. DEV.	.5	.7	26.5	.2	MAX	7.8

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey 3

SURVEY NO. 3 (CONTINUED)

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)		PH
HP	1	10.1	11.0	390.0	24.2		7.2
	2	9.6	12.0	150.0	23.5		7.3
	3	10.1	12.0	230.0	24.5		7.3
	4	9.9	12.0	--	23.8		7.3
	MEAN	9.9	11.8	256.7	24.0	MIN	7.2
	STD. DEV.	.2	.5	122.2	.4	MAX	7.3
SB-A	1	10.1	11.0	870.0	18.5		7.2
	2	10.5	11.0	600.0	18.5		7.2
	3	11.0	11.0	330.0	18.0		7.5
	4	9.5	11.1	--	18.5		7.4
	MEAN	10.3	11.0	600.0	18.4	MIN	7.2
	STD. DEV.	.6	.1	270.0	.3	MAX	7.5
SB-B	1	11.0	12.0	340.0	18.5		7.1
	2	10.5	10.2	810.0	19.0		7.2
	3	10.0	11.2	320.0	19.2		7.1
	4	11.5	11.2	--	18.5		7.5
	MEAN	10.8	11.1	490.0	18.8	MIN	7.1
	STD. DEV.	.6	.7	277.3	.4	MAX	7.5

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey 3

SURVEY NO. 3 (CONTINUED)

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)		PH
RCH-A	1	9.5	11.5	200.0	18.0		7.6
	2	9.5	11.5	340.0	18.0		7.5
	3	10.0	11.8	9.1	18.0		7.5
	4	11.0	11.3	--	17.5		7.6
	MEAN	10.0	11.5	183.0	17.9	MIN	7.5
	STD. DEV.	.7	.2	166.1	.3	MAX	7.6
RCH-B	1	10.0	12.0	140.0	18.5		7.4
	2	9.5	12.0	130.0	17.5		7.2
	3	11.0	12.0	104.0	18.2		7.4
	4	11.0	12.0	--	18.2		7.3
	MEAN	10.4	12.0	124.7	18.1	MIN	7.2
	STD. DEV.	.8	0.0	18.6	.4	MAX	7.4

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey 4

SURVEY NO. 4

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)		PH
MIS-A	1	9.2	16.0	0.0	12.0		7.5
	2	9.8	15.8	0.0	11.5		7.4
	3	10.5	15.5	0.0	10.0		7.3
	4	9.6	15.5	--	9.5		7.3
	MEAN	9.8	15.7	0.0	10.8	MIN	7.3
	STD. DEV.	.5	.2	0.0	1.2	MAX	7.5
MIS-B	1	10.1	17.0	11.0	10.0		7.1
	2	10.9	17.0	5.3	10.0		7.1
	3	10.9	17.0	8.8	9.5		7.1
	4	10.8	17.0	--	10.0		7.2
	MEAN	10.7	17.0	8.4	9.9	MIN	7.1
	STD. DEV.	.4	0.0	2.9	.3	MAX	7.2
CS-A	1	9.9	17.0	37.0	16.8		7.0
	2	11.3	16.2	420.0	17.0		7.1
	3	10.0	16.2	200.0	15.8		7.1
	4	9.6	16.5	--	16.0		7.0
	MEAN	10.2	16.5	219.0	16.4	MIN	7.0
	STD. DEV.	.8	.4	192.2	.6	MAX	7.1

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey 4

SURVEY NO. 4 (CONTINUED)

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)		PH
CS-B	1	9.2	17.0	320.0	15.5		7.0
	2	10.6	17.0	310.0	15.5		7.1
	3	8.6	16.5	--	16.0		7.1
	4	8.7	17.1	--	15.2		7.2
	MEAN	9.3	16.9	315.0	15.5	MIN	7.0
	STD. DEV.	.9	.3	7.1	.3	MAX	7.2
ALC	1	8.9	14.0	4.5	30.8		7.3
	2	8.4	13.8	1.9	--		7.3
	3	7.8	13.8	2.5	29.0		7.4
	4	7.2	14.5	--	29.0		7.2
	MEAN	8.1	14.0	3.0	29.6	MIN	7.2
	STD. DEV.	.7	.3	1.4	1.0	MAX	7.4
OIH	1	10.1	15.0	690.0	26.2		7.3
	2	11.4	16.0	620.0	26.8		7.4
	3	10.3	15.0	880.0	27.0		7.4
	4	9.0	15.5	--	26.8		7.4
	MEAN	10.2	15.4	730.0	26.7	MIN	7.3
	STD. DEV.	1.0	.5	134.5	.3	MAX	7.4

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey 4

SURVEY NO. 4 (CONTINUED)

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)		PH
HP	1	9.0	15.6	53.0	26.5		7.3
	2	10.2	15.5	90.0	26.8		7.1
	3	9.4	15.5	69.0	27.0		7.2
	4	9.9	15.5	--	26.5		7.2
	MEAN	9.6	15.5	70.7	26.7	MIN	7.1
	STD. DEV.	.5	.1	18.6	.2	MAX	7.3
SB-A	1	11.0	18.0	240.0	21.5		7.1
	2	12.0	18.0	470.0	22.0		6.9
	3	11.6	18.0	230.0	22.0		7.3
	4	12.0	18.0	--	22.0		6.9
	MEAN	11.6	18.0	313.3	21.9	MIN	6.9
	STD. DEV.	.5	0.0	135.8	.3	MAX	7.3
SB-B	1	10.5	18.0	520.0	21.5		7.4
	2	11.5	17.8	320.0	21.8		6.9
	3	11.0	17.8	490.0	22.0		6.9
	4	11.0	17.9	--	21.6		7.4
	MEAN	11.0	17.9	443.3	21.8	MIN	6.9
	STD. DEV.	.4	.1	107.9	.2	MAX	7.4

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey 4

SURVEY NO. 4 (CONTINUED)

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)		PH
RCH-A	1	10.0	18.5	450.0	22.0		7.4
	2	11.5	18.0	390.0	21.2		7.3
	3	9.0	18.5	280.0	22.0		7.2
	4	11.0	18.0	--	22.0		7.3
	MEAN	10.4	18.3	373.3	21.8	MIN	7.2
	STD. DEV.	1.1	.3	86.2	.4	MAX	7.4
RCH-B	1	10.0	18.0	120.0	20.0		7.0
	2	10.5	18.0	89.0	20.2		7.0
	3	10.0	18.1	130.0	21.0		7.1
	4	10.5	18.5	--	20.2		7.1
	MEAN	10.3	18.1	113.0	20.4	MIN	7.0
	STD. DEV.	.3	.2	21.4	.4	MAX	7.1

CUMULATIVE SEDIMENT GRAIN-SIZE CHARACTERIZATION

Cumulative Sediment Grain-Size Characterization
Survey 1

SURVEY NO. 1

PERCENTAGE DISTRIBUTION (MICRONS)

STATION	SAMPLE NO.	<991	<350	<180	<125	<63	<40	<30	<20	<15	<10	<5
MIS-A	1	98.9	98.3	97.8	97.4	94.8	93.9	89.3	78.5	72.5	63.6	51.1
	2	99.9	99.8	99.1	99.7	89.3	87.5	86.1	75.2	68.8	62.5	50.9
	3	100.0	99.8	98.8	97.6	91.8	90.2	87.2	78.0	69.3	61.2	48.8
	MEAN	99.6	99.3	98.6	98.2	92.0	90.5	87.5	77.2	70.4	62.4	50.3
	STD. DEV.	.6	.9	.7	1.3	2.8	3.2	1.6	1.8	1.9	1.2	1.3
MIS-B	1	99.9	99.7	99.5	99.4	98.5	96.7	96.7	90.7	85.8	81.5	63.6
	3	100.0	99.9	98.9	98.2	94.2	92.8	90.7	86.7	77.5	72.2	56.2
	5	100.0	99.4	98.8	98.3	95.8	94.3	92.8	85.5	80.1	72.9	54.7
	MEAN	100.0	99.7	99.1	98.6	96.2	94.6	93.4	87.6	81.2	75.5	58.2
	STD. DEV.	.1	.3	.4	.7	2.2	2.0	3.0	2.7	4.2	5.2	4.8

Cumulative Sediment Grain-Size Characterization

Survey 1

SURVEY 1 (CONTINUED)

		PERCENTAGE DISTRIBUTION (MICRONS)										
STATION	SAMPLE NO.	<991	<350	<180	<125	<43	<40	<30	<20	<15	<10	<5
CS-A	1	99.8	98.4	94.8	91.3	87.4	86.5	84.8	83.9	81.9	68.2	55.3
	3	99.3	98.7	82.9	68.7	62.9	61.0	57.7	53.0	48.8	41.8	32.4
	4	100.0	99.2	97.8	96.6	93.7	93.0	91.9	86.5	79.3	72.5	58.6
	MEAN	99.7	98.8	91.8	85.5	81.3	80.2	78.1	74.5	70.0	60.8	48.8
	STD. DEV.	.4	.4	7.9	14.8	16.3	16.9	18.0	18.6	18.4	16.6	14.3
CS-B	1	99.1	96.8	72.7	39.8	27.4	26.8	25.9	23.6	22.2	19.8	15.6
	2	99.4	99.0	93.8	86.3	77.0	74.5	71.5	66.8	62.4	55.1	43.4
	4	98.9	96.5	80.0	64.1	52.1	49.7	49.2	43.5	40.0	38.0	27.9
	MEAN	99.1	97.4	82.2	63.4	52.2	50.3	48.9	44.6	41.5	37.6	29.0
	STD. DEV.	.3	1.4	10.7	23.3	24.8	23.9	22.8	21.6	20.1	17.7	13.9

Cumulative Sediment Grain-Size Characterization
Survey 1

SURVEY 1 (CONTINUED)

STATION	SAMPLE NO.	PERCENTAGE DISTRIBUTION (MICRONS)										
		<991	<350	<180	<125	<43	<40	<30	<20	<15	<10	<5
ALC	2	99.7	89.4	16.5	3.6	3.0	2.8	2.8	2.7	2.3	2.2	1.8
	4	99.9	89.4	23.1	3.8	2.6	2.3	2.1	1.8	1.7	1.7	1.5
	5	99.8	91.6	25.8	3.0	1.6	1.6	1.5	1.2	1.0	1.0	.6
	MEAN	99.8	90.1	21.8	3.5	2.4	2.2	2.1	1.9	1.7	1.6	1.3
	STD. DEV.	.1	1.3	4.8	.4	.7	.6	.7	.8	.7	.6	.6
DIH	1	99.8	97.9	76.5	55.3	40.2	38.5	37.4	37.3	36.8	36.3	21.7
	2	99.3	97.7	68.8	42.0	28.6	28.4	27.7	24.8	23.0	21.8	18.3
	4	99.2	97.0	87.7	78.4	66.0	64.6	59.5	55.2	48.0	44.3	35.7
	MEAN	99.4	97.5	77.7	58.6	44.9	43.8	41.5	39.1	35.9	34.1	25.2
	STD. DEV.	.3	.5	9.5	18.4	19.1	18.7	16.3	15.3	12.5	11.4	9.2
HP	3	99.6	97.8	92.3	87.2	76.4	73.4	68.5	62.6	55.9	52.0	43.8
	5	96.2	93.5	82.1	75.6	67.1	65.9	63.4	57.9	55.2	49.5	42.9
	MEAN	97.9	95.7	87.2	81.4	71.7	69.7	65.9	60.2	55.5	50.7	43.3
	STD. DEV.	2.4	3.0	7.2	8.2	6.6	5.3	3.6	3.3	.5	1.8	.6

SURVEY 1 (CONTINUED)

STATION	SAMPLE NO.	PERCENTAGE DISTRIBUTION (MICRONS) <991	<350	<180	<125	<63	<40	<30	<20	<15	<10	<5
SB-A	1	97.0	90.0	84.2	83.0	81.8	79.6	80.6	76.8	71.7	65.1	56.6
	3	99.9	99.2	98.6	98.3	97.4	97.4	94.1	87.2	83.5	75.2	62.0
	4	99.9	98.8	97.6	96.9	95.8	94.8	93.1	87.7	77.0	73.2	67.6
	MEAN	98.9	96.0	93.5	92.7	91.7	90.6	89.3	83.9	77.4	71.2	62.1
	STD. DEV.	1.7	5.2	8.0	8.5	8.6	9.6	7.5	6.2	6.0	5.3	5.5
SB-B	2	100.0	99.8	99.5	99.1	96.2	88.7	85.7	79.8	74.5	66.8	54.2
	3	99.0	98.9	98.2	97.6	96.0	90.2	88.1	76.4	70.3	63.6	54.0
	4	99.9	99.4	98.8	98.0	93.5	93.2	88.2	77.4	70.1	62.5	53.1
	MEAN	99.6	99.4	98.8	98.2	95.2	90.7	87.3	77.9	71.6	64.3	53.8
	STD. DEV.	.6	.5	.7	.8	1.5	2.3	.4	1.7	2.5	2.2	.6

Cumulative Sediment Grain-Size Characterization
Survey 1

SURVEY 1 (CONTINUED)

STATION	SAMPLE NO.	PERCENTAGE DISTRIBUTION (MICRONS) <991	<350	<180	<125	<43	<40	<30	<20	<15	<10	<5
RCH-A	2	98.8	98.0	96.4	95.1	93.3	93.1	90.2	81.4	76.2	67.8	58.5
	3	98.8	97.2	93.3	90.8	88.3	88.2	83.6	78.3	72.6	63.5	61.5
	4	96.6	95.2	91.0	88.0	85.1	83.0	82.0	75.8	71.7	64.6	54.4
	MEAN	98.1	96.8	93.6	91.3	88.9	88.1	85.3	78.5	73.5	65.3	58.1
	STD. DEV.	1.3	1.4	2.7	3.6	4.1	5.1	4.3	2.8	2.4	2.2	3.6
RCH-B	1	100.0	98.8	97.7	97.0	94.7	94.9	94.0	88.8	80.6	72.9	58.7
	3	99.9	98.4	97.5	96.9	94.6	93.1	91.0	83.1	76.4	67.1	54.4
	4	99.9	99.4	97.5	96.4	92.8	93.9	90.6	81.7	78.8	70.7	58.7
	MEAN	99.9	98.9	97.6	96.8	94.0	94.0	91.9	84.5	78.6	70.2	57.3
	STD. DEV.	.1	.5	.1	.3	1.1	.9	1.9	3.8	2.1	2.9	2.5

Cumulative Sediment Grain-Size Characterization
Survey 2

SURVEY NO. 2

PERCENTAGE DISTRIBUTION (MICRONS)

STATION	SAMPLE NO.	<991	<350	<180	<125	<43	<40	<30	<20	<15	<10	<5
MIS-A	1	99.6	99.4	99.2	99.1	95.7	97.6	94.6	86.8	56.2	25.9	7.4
	3	98.4	98.0	97.7	97.6	96.2	96.0	94.5	82.5	43.4	10.8	10.2
	5	98.8	98.5	98.4	98.4	97.0	97.7	95.8	76.6	39.0	9.3	1.4
	MEAN	98.9	98.6	98.4	98.4	96.3	97.1	95.0	82.0	46.2	15.3	6.3
	STD. DEV.	.6	.7	.8	.8	.7	1.0	.7	5.1	8.9	9.2	4.5
MIS-B	1	99.9	99.5	99.2	98.9	95.3	94.9	91.7	63.7	24.4	9.0	4.8
	3	99.3	98.8	98.5	98.2	95.2	93.9	93.8	65.3	27.9	10.7	7.8
	5	99.5	99.0	98.6	98.2	94.3	96.0	90.4	61.1	16.3	9.3	1.8
	MEAN	99.6	99.1	98.8	98.4	94.9	94.9	92.0	63.4	22.9	9.7	4.8
	STD. DEV.	.3	.4	.4	.4	.6	1.1	1.7	2.1	6.0	.9	3.0

Cumulative Sediment Grain-Size Characterization
Survey 2

SURVEY 2 (CONTINUED)

STATION	SAMPLE NO.	PERCENTAGE DISTRIBUTION (MICRONS) <991	<350	<180	<125	<43	<40	<30	<20	<15	<10	<5
CS-A	1	99.3	98.8	97.5	94.8	90.0	90.0	88.9	74.6	42.7	13.4	2.7
	3	99.1	98.0	95.1	91.1	86.7	84.4	82.9	82.7	67.6	16.1	10.5
	5	98.7	97.7	95.4	91.7	86.2	87.2	86.1	80.5	25.6	5.8	10.4
	MEAN	99.0	98.2	96.0	92.5	87.6	87.2	86.0	79.3	45.3	11.8	7.9
	STD. DEV.	.3	.6	1.3	2.0	2.1	2.8	3.0	4.2	21.1	5.3	4.5
CS-B	1	99.6	98.7	91.1	79.1	70.8	71.0	70.9	64.1	33.2	7.7	2.8
	3	97.0	94.2	66.8	48.2	42.0	41.5	41.5	26.6	27.6	11.1	2.1
	5	99.3	98.4	94.6	89.7	82.8	80.0	82.5	77.8	60.1	5.3	1.3
	MEAN	98.6	97.1	84.2	72.3	65.2	64.2	65.0	56.2	40.3	8.0	2.1
	STD. DEV.	1.4	2.5	25.1	21.6	21.0	20.1	21.1	26.5	17.4	2.9	.8

Cumulative Sediment Grain-Size Characterization
Survey 2

SURVEY 2 (CONTINUED)

STATION	SAMPLE NO.	<991	<350	<180	<125	<43	<40	<30	<20	<15	<10	<5
		PERCENTAGE DISTRIBUTION (MICRONS)										
ALC	1	100.0	99.9	99.6	99.3	96.3	94.9	91.2	86.9	76.5	36.1	4.0
	3	99.9	99.7	99.0	98.4	90.7	92.7	93.4	85.2	66.5	4.6	6.6
	5	97.3	92.1	81.0	78.3	70.4	69.5	75.2	70.7	40.7	4.1	.6
	MEAN	99.1	97.2	93.2	92.0	85.1	85.7	86.6	80.9	61.2	14.9	3.7
	STD. DEV.	1.5	4.4	10.6	11.9	12.9	14.1	9.9	8.9	18.5	18.3	3.0
OIH	1	98.7	96.2	66.4	44.1	31.3	30.7	28.8	23.0	12.2	4.8	2.1
	3	99.1	96.8	63.6	39.2	26.3	26.6	24.6	21.6	14.4	6.9	.4
	5	99.1	96.3	66.6	45.1	32.8	32.7	30.4	26.6	12.1	3.3	1.8
	MEAN	99.0	96.4	65.5	42.8	30.1	30.0	27.9	23.7	12.9	5.0	1.4
	STD. DEV.	.2	.3	1.7	3.2	3.4	3.1	3.0	2.6	1.3	1.8	.9

Cumulative Sediment Grain-Size Characterization
Survey 2

SURVEY 2 (CONTINUED)

STATION	SAMPLE NO.	PERCENTAGE DISTRIBUTION (MICRONS) <991	<350	<180	<125	<43	<40	<30	<20	<15	<10	<5
HP	1	74.5	71.9	70.6	68.4	59.2	58.9	53.9	51.6	39.5	14.0	4.3
	3	93.5	92.1	90.5	86.3	74.3	72.9	70.9	57.1	31.3	9.8	.3
	5	91.8	90.3	88.6	84.7	73.8	72.7	67.1	58.7	31.1	13.9	8.6
	MEAN	86.6	84.8	83.2	79.8	69.1	68.2	64.0	55.8	34.0	12.6	4.4
	STD. DEV.	10.5	11.2	11.0	9.9	8.6	8.0	8.9	3.7	4.8	2.4	4.2
SB-A	1	74.6	58.3	46.4	43.0	38.4	37.3	37.0	32.5	27.9	5.4	.1
	3	78.8	60.3	49.6	46.8	43.4	43.4	41.6	40.2	37.1	13.1	2.3
	5	54.5	35.3	24.8	22.6	19.8	19.7	20.5	17.4	17.0	1.9	0.0
	MEAN	69.3	51.3	40.3	37.5	33.9	33.5	33.0	30.0	27.3	6.8	.8
	STD. DEV.	13.0	13.9	13.5	13.0	12.4	12.3	11.1	11.6	10.1	5.7	1.3

SURVEY 2 (CONTINUED)

STATION	SAMPLE NO.	PERCENTAGE DISTRIBUTION (MICRONS) <991	<350	<180	<125	<43	<40	<30	<20	<15	<10	<5
SB-B	1	92.7	90.8	89.0	87.5	81.8	84.1	78.1	74.3	61.3	16.4	4.0
	3	100.0	99.9	99.9	99.8	93.6	98.6	91.4	86.8	66.0	5.4	4.4
	5	99.9	99.7	99.6	99.5	94.6	97.9	97.4	93.1	64.5	17.2	.1
	MEAN	97.5	96.8	96.2	95.6	90.0	93.5	89.0	84.7	63.9	13.0	2.8
	STD. DEV.	4.2	5.2	6.2	7.0	7.1	8.2	9.9	9.6	2.4	6.6	2.4
RCH-A	1	99.5	97.8	81.6	74.3	71.5	71.4	68.7	64.7	38.2	10.3	4.0
	3	93.4	92.2	87.5	84.9	79.4	82.4	81.0	73.0	49.2	8.8	4.9
	5	98.6	98.1	97.5	96.9	95.1	94.5	98.0	86.7	59.7	8.3	2.3
	MEAN	97.2	96.0	88.9	85.4	82.0	82.8	82.6	74.8	49.0	9.1	3.7
	STD. DEV.	3.3	3.3	8.0	11.3	12.0	11.6	14.7	11.1	10.8	1.0	1.3

Cumulative Sediment Grain-Size Characterization
Survey 2

SURVEY 2 (CONTINUED)

STATION	SAMPLE NO.	PERCENTAGE DISTRIBUTION (MICRONS) <991	<350	<180	<125	<43	<40	<30	<20	<15	<10	<5
RCH-B	1	99.9	99.7	99.6	99.4	97.6	98.1	97.8	87.1	46.4	11.1	3.4
	3	100.0	99.5	99.1	98.9	97.4	97.1	92.7	66.8	17.7	7.2	5.5
	5	99.4	99.0	98.6	98.2	96.0	93.3	96.8	69.8	20.1	16.1	8.6
	MEAN	99.8	99.4	99.1	98.8	97.0	96.2	95.8	74.6	28.1	11.5	5.8
	STD. DEV.	.3	.4	.5	.6	.9	2.5	2.7	11.0	15.9	4.5	2.6

Cumulative Sediment Grain-Size Characterization
Survey 3

SURVEY NO. 3

PERCENTAGE DISTRIBUTION (MICRONS)

STATION	SAMPLE NO.	<991	<350	<180	<125	<43	<40	<30	<20	<15	<10	<5
MIS-A	1	100.0	99.0	98.4	98.0	95.7	95.5	91.6	88.5	81.7	72.8	59.1
	2	100.0	99.4	98.9	98.7	97.1	88.7	96.1	93.4	90.5	80.1	62.8
	3	100.0	99.8	99.4	99.1	97.6	96.1	90.8	86.1	80.8	73.0	60.4
	MEAN	100.0	99.4	98.9	98.6	96.8	93.4	92.8	89.3	84.3	75.3	60.8
	STD. DEV.	0.0	.4	.5	.6	1.0	4.1	2.9	3.7	5.4	4.2	1.9
MIS-B	1	99.9	99.3	98.7	98.2	94.3	93.1	91.4	85.2	77.7	68.2	55.7
	2	99.9	99.0	98.3	97.7	93.3	87.4	85.4	78.5	75.1	67.1	53.2
	3	100.0	99.1	98.4	98.0	94.9	94.5	92.4	86.5	80.4	71.6	58.6
	MEAN	99.9	99.1	98.5	98.0	94.2	91.7	89.7	83.4	77.7	69.0	55.8
	STD. DEV.	.1	.2	.2	.3	.8	3.8	3.8	4.3	2.7	2.3	2.7

Cumulative Sediment Grain-Size Characterization
Survey 3

SURVEY 3 (CONTINUED)

STATION	SAMPLE NO.	PERCENTAGE DISTRIBUTION (MICRONS)										
		<991	<350	<180	<125	<43	<40	<30	<20	<15	<10	<5
CS-A	1	98.6	89.4	53.9	31.6	24.7	24.3	23.5	20.6	19.9	17.9	14.4
	2	98.7	83.8	40.3	20.1	16.5	15.7	15.4	14.8	13.9	13.2	11.5
	3	95.4	81.9	46.8	28.7	25.1	24.0	23.6	21.9	20.3	18.5	15.1
	MEAN	97.6	85.0	47.0	26.8	22.1	21.3	20.8	19.1	18.0	16.5	13.7
	STD. DEV.	1.9	3.9	6.8	6.8	4.9	4.9	4.7	3.8	3.6	2.9	1.9
CS-B	1	98.0	94.5	62.9	45.9	39.1	38.9	38.6	37.1	31.2	27.9	25.4
	2	99.2	96.9	77.0	65.3	59.4	57.5	56.9	53.7	49.5	44.6	36.7
	3	99.4	96.1	65.9	51.3	46.0	45.7	44.3	42.3	39.0	35.7	29.2
	MEAN	98.9	95.8	68.6	54.2	48.2	47.4	46.6	44.4	39.9	36.1	30.4
	STD. DEV.	.8	1.2	7.4	10.0	10.3	9.4	9.4	9.5	9.2	8.4	5.8

SURVEY 3 (CONTINUED)

STATION	SAMPLE NO.	PERCENTAGE DISTRIBUTION (MICRONS) <991	<350	<180	<125	<43	<40	<30	<20	<15	<10	<5
ALC	1	97.1	96.5	91.8	88.5	84.8	78.1	72.4	66.9	62.3	55.7	45.1
	3	99.2	98.7	97.0	95.8	92.6	92.5	87.9	81.3	75.2	68.5	55.1
	4	94.9	94.1	89.6	87.4	82.9	81.4	80.5	73.3	68.0	61.0	49.3
	MEAN	97.1	96.4	92.8	90.6	86.8	84.0	80.3	73.8	68.5	61.7	49.8
	STD. DEV.	2.2	2.3	3.8	4.6	5.1	7.5	7.8	7.2	6.5	6.4	5.0
OIH	1	99.8	98.2	71.9	49.1	36.5	34.2	31.4	30.2	27.4	25.5	19.9
	2	99.5	97.4	66.4	45.5	35.1	34.2	32.5	30.2	29.9	26.3	20.7
	3	99.3	97.8	71.3	48.6	36.0	32.6	32.7	29.3	27.0	25.0	20.9
	MEAN	99.5	97.8	69.9	47.7	35.9	33.7	32.2	29.9	28.1	25.6	20.5
	STD. DEV.	.3	.4	3.0	2.0	.7	.9	.7	.5	1.6	.7	.5

Cumulative Sediment Grain-Size Characterization
Survey 3

SURVEY 3 (CONTINUED)

STATION	SAMPLE NO.	PERCENTAGE DISTRIBUTION (MICRONS) <991	<350	<180	<125	<43	<40	<30	<20	<15	<10	<5
HP	1	96.1	94.4	92.0	88.7	80.0	72.4	71.9	64.4	59.9	53.7	43.4
	2	99.8	98.5	95.2	88.7	74.3	70.0	66.4	61.1	55.6	51.2	42.0
	3	92.7	91.7	91.7	87.9	75.4	70.5	66.5	67.4	60.5	55.5	46.2
	MEAN	96.2	94.9	93.0	88.4	76.6	71.0	68.3	64.3	58.7	53.5	43.9
	STD. DEV.	3.6	3.4	1.9	.5	3.0	1.3	3.1	3.2	2.7	2.2	2.1
SB-A	1	99.9	99.6	99.1	98.8	97.2	87.4	87.0	80.3	72.0	66.1	54.0
	2	97.0	96.3	95.4	94.8	88.8	91.2	79.3	80.0	72.4	65.0	54.7
	3	96.0	94.8	93.6	92.7	89.1	82.6	80.8	75.5	69.2	63.5	52.7
	MEAN	97.6	96.9	96.0	95.4	91.7	87.1	82.4	78.6	71.2	64.9	53.8
	STD. DEV.	2.0	2.5	2.8	3.1	4.8	4.3	4.1	2.7	1.7	1.3	1.0

Cumulative Sediment Grain-Size Characterization
Survey 3

SURVEY 3 (CONTINUED)

STATION	SAMPLE NO.	PERCENTAGE DISTRIBUTION (MICRONS) <991	<350	<180	<125	<43	<40	<30	<20	<15	<10	<5
SB-8	1	96.4	95.5	94.8	94.2	91.7	89.9	85.5	77.3	71.9	63.5	50.5
	2	99.7	99.3	98.7	98.1	95.4	94.9	87.2	79.9	74.1	70.0	53.0
	3	99.7	99.2	98.6	98.1	95.7	94.1	92.0	89.3	82.8	74.6	60.6
	MEAN	98.6	98.0	97.4	96.8	94.3	93.0	88.2	82.2	76.3	69.4	54.7
	STD. DEV.	1.9	2.2	2.2	2.3	2.2	2.7	3.4	6.3	5.8	5.6	5.3
RCH-A	1	98.9	98.3	97.7	96.0	92.1	92.0	88.3	82.9	76.1	68.6	59.3
	2	99.1	98.7	98.1	96.4	92.9	91.5	87.7	85.4	75.7	69.3	56.0
	3	94.5	93.6	92.5	90.6	87.0	85.9	81.9	75.4	68.6	64.0	52.5
	MEAN	97.5	96.9	96.1	94.3	90.7	89.8	86.0	81.2	73.5	67.3	55.9
	STD. DEV.	2.6	2.8	3.1	3.2	3.2	3.4	3.5	5.2	4.2	2.9	3.4

Cumulative Sediment Grain-Size Characterization
Survey 3

SURVEY 3 (CONTINUED)

STATION	SAMPLE NO.	PERCENTAGE DISTRIBUTION (MICRONS) <991	<350	<180	<125	<43	<40	<30	<20	<15	<10	<5
RCH-B	1	99.5	93.9	98.3	97.9	95.6	93.5	91.5	88.3	79.3	73.1	60.0
	2	99.6	99.2	98.7	98.4	96.2	91.0	90.3	89.8	83.0	79.4	62.5
	3	99.8	99.3	99.0	98.8	97.1	93.7	89.1	82.5	77.1	70.6	58.5
	MEAN	99.6	99.1	98.7	98.4	96.3	92.7	90.3	86.9	79.8	74.4	60.3
	STD. DEV.	.2	.2	.4	.5	.8	1.5	1.2	3.9	3.0	4.5	2.0

Cumulative Sediment Grain-Size Characterization
Survey 4

SURVEY NO. 4

PERCENTAGE DISTRIBUTION (MICRONS)

STATION	SAMPLE NO.	<991	<350	<180	<125	<43	<40	<30	<20	<15	<10	<5
MIS-A	1	100.0	99.6	99.2	99.0	98.2	97.5	97.0	92.7	87.2	81.0	64.3
	2	100.0	99.5	99.3	99.2	99.1	95.2	96.4	92.1	86.5	79.8	63.8
	3	100.0	99.7	99.4	99.2	99.0	98.7	96.9	96.5	91.4	81.7	41.7
	MEAN	100.0	99.6	99.3	99.1	98.8	97.1	96.8	93.8	88.4	80.8	56.6
	STD. DEV.	0.0	.1	.1	.1	.5	1.8	.3	2.4	2.7	1.0	12.9
MIS-B	1	98.4	97.9	97.5	97.2	95.2	95.1	90.5	85.7	78.7	72.6	52.0
	2	99.9	99.4	99.1	98.8	96.7	95.1	92.2	86.2	81.4	72.8	56.5
	3	100.0	99.6	99.3	99.1	99.0	98.8	95.4	90.6	82.3	73.7	53.4
	MEAN	99.4	99.0	98.6	98.4	97.0	96.3	92.7	87.5	80.8	73.0	54.0
	STD. DEV.	.9	.9	1.0	1.0	1.9	2.1	2.5	2.7	1.9	.6	2.3

Cumulative Sediment Grain-Size Characterization
Survey 4

SURVEY 4 (CONTINUED)

		PERCENTAGE DISTRIBUTION (MICRONS)										
STATION	SAMPLE NO.	<991	<350	<180	<125	<43	<40	<30	<20	<15	<10	<5
CS-A	1	98.1	96.9	89.6	82.8	77.2	78.1	77.6	71.2	67.5	52.0	46.6
	2	99.6	98.2	90.0	84.5	78.2	80.9	78.5	73.6	67.9	61.3	48.8
	3	96.3	91.5	65.8	47.2	42.4	43.8	44.3	41.0	37.4	33.7	26.5
	MEAN	98.0	95.5	81.8	71.5	65.9	67.6	66.8	61.9	57.5	49.0	40.6
	STD. DEV.	1.7	3.6	13.9	21.1	20.4	20.7	19.5	18.2	17.5	14.0	12.3
CS-B	1	99.5	97.1	85.6	66.8	48.8	47.0	46.1	43.3	39.8	36.0	29.3
	2	99.6	98.1	87.6	67.5	49.3	47.6	47.4	44.8	42.0	37.8	30.2
	3	99.8	98.5	82.0	86.9	45.4	44.6	43.2	40.9	38.3	35.0	28.9
	MEAN	99.6	97.9	85.1	73.7	47.8	46.4	45.6	43.0	40.0	36.3	29.5
	STD. DEV.	.2	.7	2.8	11.4	2.1	1.6	2.2	2.0	1.9	1.4	.7

SURVEY 4 (CONTINUED)

		PERCENTAGE DISTRIBUTION (MICRONS)										
STATION	SAMPLE NO.	<991	<350	<180	<125	<43	<40	<30	<20	<15	<10	<5
ALC	1	100.0	92.3	20.1	1.9	.7	.3	.1	.1	.1	.1	.1
	2	99.9	88.9	14.6	1.0	.3	.3	.2	.1	.1	.1	.1
	3	100.0	94.0	19.0	1.4	.5	.4	.4	.2	.2	.1	0.0
	MEAN	100.0	91.7	17.9	1.4	.5	.3	.2	.1	.1	.1	.1
	STD. DEV.	.1	2.6	2.9	.5	.2	.1	.2	.1	.1	.0	.1
OTH	1	99.5	95.0	59.4	42.0	31.4	30.3	30.1	28.1	26.1	23.4	17.8
	2	98.1	93.6	58.9	42.1	33.0	31.0	30.4	27.7	25.3	22.6	18.8
	3	98.9	95.0	64.4	47.5	37.0	35.3	32.2	30.9	28.0	25.1	20.8
	MEAN	98.8	94.5	60.9	43.9	33.8	32.2	30.9	28.9	26.5	23.7	19.1
	STD. DEV.	.7	.8	3.0	3.1	2.9	2.7	1.1	1.7	1.4	1.3	1.5

Cumulative Sediment Grain-Size Characterization
Survey 4

SURVEY 4 (CONTINUED)

STATION	SAMPLE NO.	<991	<350	<180	<125	<43	<40	<30	<20	<15	<10	<5
		PERCENTAGE DISTRIBUTION (MICRONS)										
HP	1	98.8	97.6	95.8	92.5	79.8	78.5	78.0	70.2	63.3	60.8	52.8
	2	93.4	91.8	89.9	87.1	77.0	71.0	70.1	68.1	60.1	59.4	50.2
	3	99.8	98.2	96.2	93.5	84.1	77.7	78.6	72.4	66.9	60.2	51.2
	MEAN	97.3	95.9	94.0	91.0	80.3	75.7	75.6	70.2	63.4	60.1	51.4
	STD. DEV.	3.4	3.5	3.5	3.4	3.6	4.1	4.7	2.2	3.4	.7	1.3
SB-A	1	89.9	76.9	64.8	63.9	62.9	58.8	58.0	54.5	50.4	44.2	33.4
	2	99.7	98.9	97.8	97.2	94.3	92.4	87.9	78.7	70.7	62.8	51.6
	3	82.3	62.8	49.1	47.4	44.1	45.6	45.1	40.3	36.7	33.2	25.4
	MEAN	90.6	79.5	70.6	69.5	67.1	65.6	63.7	57.8	52.6	46.7	36.8
	STD. DEV.	8.7	18.2	24.9	25.4	25.4	24.1	22.0	19.4	17.1	15.0	13.4

SURVEY 4 (CONTINUED)

STATION	SAMPLE NO.	PERCENTAGE DISTRIBUTION (MICRONS) <991	<350	<180	<125	<43	<40	<30	<20	<15	<10	<5
SB-8	1	99.0	98.5	98.1	97.8	96.0	91.4	89.8	82.6	73.1	64.3	47.7
	2	100.0	99.3	98.7	98.2	97.6	90.5	46.1	16.8	12.5	9.6	5.0
	3	100.0	99.2	98.7	98.4	97.8	92.2	88.3	80.5	66.5	55.3	34.6
	MEAN	99.7	99.0	98.5	98.1	97.1	91.4	74.7	60.0	50.7	43.1	29.1
	STD. DEV.	.6	.4	.3	.3	1.0	.9	24.8	37.4	33.2	29.3	21.9
RCH-A	1	92.5	89.2	81.2	70.4	64.5	62.9	61.5	56.2	52.9	48.4	40.4
	2	90.9	88.4	83.2	77.1	73.7	73.7	72.3	66.0	60.6	55.4	46.0
	3	90.0	86.1	80.0	73.3	71.8	70.3	67.2	63.7	59.7	54.0	44.8
	MEAN	91.1	87.9	81.5	73.6	70.0	69.0	67.0	62.0	57.7	52.6	43.7
	STD. DEV.	1.3	1.6	1.6	3.4	4.9	5.5	5.4	5.1	4.2	3.7	2.9

SURVEY 4 (CONTINUED)

		PERCENTAGE DISTRIBUTION (MICRONS)										
STATION	SAMPLE NO.	<991	<350	<180	<125	<43	<40	<30	<20	<15	<10	<5
RCH-8	1	99.9	99.5	99.3	99.1	97.8	97.5	93.8	86.4	80.2	73.1	61.2
	2	99.9	99.1	98.7	98.5	96.8	90.2	91.5	84.5	78.9	70.8	58.9
	3	99.7	99.3	99.0	98.7	97.0	95.9	94.3	85.8	79.5	71.7	59.1
	MEAN	99.8	99.3	99.0	98.8	97.2	94.5	93.2	85.6	79.5	71.9	59.7
	STD. DEV.	.1	.2	.3	.3	.5	3.8	1.5	1.0	.7	1.2	1.3

CATEGORICAL SEDIMENT GRAIN-SIZE CHARACTERIZATION

Categorical Sediment Grain-Size Characterization
Survey 1

SURVEY NO. 1
PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS)

STATION	SAMPLE NO.	>991	350-990	180-349	125-179	4.-124	40-42	30-39	20-29	15-19	10-14	5-9	<5
MIS-A	1	1.1	.6	.5	.4	2.6	.9	4.6	10.8	6.0	8.9	12.5	51.1
	2	.1	.1	.7	-.6	10.4	1.8	1.4	10.9	6.4	6.3	11.6	50.9
	3	0.0	.2	1.0	1.2	5.8	1.6	3.0	9.2	8.1	8.7	12.4	48.8
	MEAN	.4	.3	.7	.3	6.3	1.4	3.0	10.3	6.8	8.0	12.2	50.3
	STD. DEV.	.6	.3	.3	.9	3.9	.5	1.6	1.0	1.1	1.4	.5	1.3
MIS-B	1	.1	.2	.2	.1	.9	1.8	0.0	6.0	4.9	4.3	17.9	63.6
	3	0.0	.1	1.0	.7	4.0	1.4	2.1	4.0	9.1	5.4	16.0	56.2
	5	0.0	.6	.6	.5	2.5	1.5	1.5	7.3	5.4	7.2	18.2	54.7
	MEAN	.0	.3	.6	.4	2.5	1.6	1.2	5.8	6.5	5.6	17.4	58.2
	STD. DEV.	.1	.3	.4	.3	1.6	.2	1.1	1.7	2.3	1.5	1.2	4.8

Categorical Sediment Grain-Size Characterization
Survey 1

SURVEY 1 (CONTINUED)

PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS)

STATION	SAMPLE NO.	>991	350-990	180-349	125-179	43-124	40-42	30-39	20-29	15-19	10-14	5-9	<5
CS-A	1	.2	1.4	3.6	3.5	3.9	.9	1.7	.9	2.0	13.7	12.9	55.3
	3	.7	.6	15.8	14.2	5.8	1.9	3.3	4.7	4.2	7.0	9.4	32.4
	4	0.0	.8	1.4	1.2	2.9	.7	1.1	5.4	7.2	6.8	13.9	58.5
	MEAN	.3	.9	6.9	6.3	4.2	1.2	2.0	3.7	4.5	9.2	12.1	48.8
	STD. DEV.	.4	.4	7.8	6.9	1.5	.6	1.1	2.4	2.6	1.9	2.4	14.3
CS-B	1	.9	2.3	24.1	32.9	12.4	.6	.9	2.3	1.4	2.4	4.2	15.6
	2	.6	.4	5.2	7.5	9.3	2.5	3.0	4.7	4.4	7.2	11.7	43.4
	4	1.1	2.4	16.5	15.9	12.0	2.4	.5	5.7	3.5	2.0	10.1	27.9
	MEAN	.9	1.7	15.3	18.8	11.2	1.8	1.5	4.2	3.1	3.9	8.7	29.0
	STD. DEV.	.3	1.1	9.5	12.9	1.7	1.1	1.3	1.7	1.5	3.0	4.0	13.9

Categorical Sediment Grain-Size Characterization
Survey 1

SURVEY 1 (CONTINUED)

STATION	SAMPLE NO.	>991	350-990	180-349	125-179	43-124	40-42	30-39	20-29	15-19	10-14	5-9	<5
		PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS)											
ALC	2	.3	10.3	72.9	12.9	.6	.2	0.0	.1	.4	.1	.4	1.8
	4	.1	10.5	66.3	19.3	1.2	.3	.2	.3	.1	0.0	.2	1.5
	5	.2	8.2	65.8	22.8	1.4	0.0	.1	.3	.2	0.0	.4	.6
	MEAN	.2	9.7	68.3	18.3	1.1	.2	.1	.2	.2	.0	.3	1.3
	STD. DEV.	.1	1.3	4.0	5.0	.4	.2	.1	.1	.2	.1	.1	.6
OIH	1	.2	1.9	21.4	21.2	15.1	1.7	1.1	.1	.5	.5	14.6	21.7
	2	.7	1.6	28.9	26.8	13.4	.2	.7	2.9	1.8	1.2	3.5	18.3
	4	.8	2.2	9.3	9.3	12.4	1.4	5.1	4.3	7.2	3.7	8.6	35.7
	MEAN	.6	1.9	19.9	19.1	13.6	1.1	2.3	2.4	3.2	1.8	8.9	25.2
	STD. DEV.	.3	.3	9.9	8.9	1.4	.8	2.4	2.1	3.6	1.7	5.6	9.2
HP	3	.4	1.8	5.5	5.1	10.8	3.0	4.9	5.9	6.7	3.9	8.2	43.8
	5	3.8	2.7	11.4	6.5	8.5	1.2	2.5	5.5	2.7	5.7	6.6	42.9
	MEAN	2.1	2.2	6.5	5.8	9.6	2.1	3.7	5.7	4.7	4.8	7.4	43.3
	STD. DEV.	2.4	.6	4.2	1.0	1.6	1.3	1.7	.3	2.8	1.3	1.1	.6

Categorical Sediment Grain-Size Characterization
Survey 1

SURVEY 1 (CONTINUED)

PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS)

STATION	SAMPLE NO.	>991	350-990	180-349	125-179	43-124	40-42	30-39	20-29	15-19	10-14	5-9	<5
SB-A	1	3.0	7.0	5.8	1.2	1.2	2.2	-1.0	3.8	5.1	6.6	8.5	56.5
	3	.1	.7	.6	.3	.9	0.0	3.3	6.9	3.6	8.4	13.2	62.0
	4	.1	1.1	1.2	.7	1.1	1.0	1.7	5.4	10.7	3.8	5.6	67.6
	MEAN	1.1	2.9	2.5	.7	1.1	1.1	1.3	5.4	6.5	6.3	9.1	62.1
	STD. DEV.	1.7	3.5	2.8	.5	.2	1.1	2.2	1.6	3.7	2.3	3.8	5.5
SB-B	2	0.0	.2	.3	.4	2.9	7.5	3.0	5.9	5.3	7.7	12.6	54.2
	3	1.0	.1	.7	.6	1.6	5.8	2.1	11.7	6.1	6.7	9.6	54.0
	4	.1	.5	.6	.8	4.5	.3	5.0	10.8	7.3	7.6	9.4	53.1
	MEAN	.4	.3	.5	.6	3.0	4.5	3.4	9.5	6.2	7.3	10.5	53.9
	STD. DEV.	.6	.2	.2	.2	1.5	3.8	1.5	3.1	1.0	.6	1.8	.6

Categorical Sediment Grain-Size Characterization
Survey 1

SURVEY 1 (CONTINUED)

STATION	SAMPLE NO.	PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS)											
		>991	350-990	180-349	125-179	43-124	40-42	30-39	20-29	15-19	10-14	5-9	<5
RCH-A	2	1.2	.8	1.6	1.3	1.8	.2	2.9	8.8	5.2	8.4	9.3	58.5
	3	1.2	1.6	3.9	2.5	2.5	.1	4.6	5.3	5.7	9.1	2.0	61.5
	4	3.4	1.4	4.2	3.0	2.9	2.1	1.0	6.2	4.1	7.1	10.2	54.4
	MEAN	1.9	1.3	3.2	2.3	2.4	.8	2.8	6.8	5.0	8.2	7.2	58.1
	STD. DEV.	1.3	.4	1.4	.9	.6	1.1	1.8	1.8	.8	1.0	4.5	3.6
RCH-B	1	0.0	1.2	1.1	.7	2.3	-.2	.9	5.2	8.2	7.7	14.2	58.7
	3	.1	1.5	.9	.6	2.3	1.5	2.1	7.9	6.7	9.3	12.7	54.4
	4	.1	.5	1.9	1.1	3.6	-1.1	3.3	8.9	2.9	8.1	12.0	58.7
	MEAN	.1	1.1	1.3	.8	2.7	.1	2.1	7.3	5.9	8.4	13.0	57.3
	STD. DEV.	.1	.5	.5	.3	.8	1.3	1.2	1.9	2.7	.8	1.1	2.5

Categorical Sediment Grain-Size Characterization
Survey 2

SURVEY NO. 2
PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS)

STATION	SAMPLE NO.	>991	350-990	180-349	125-179	43-124	40-42	30-39	20-29	15-19	10-14	5-9	<5
MIS-A	1	.4	.2	.2	.1	3.4	-1.9	3.0	7.8	30.6	30.3	18.5	7.4
	3	1.6	.4	.3	.1	1.4	.2	1.5	12.0	39.1	32.6	.6	10.2
	5	1.2	.3	.1	0.0	1.4	-.7	1.9	19.2	37.6	29.7	7.9	1.4
	MEAN	1.1	.3	.2	.1	2.1	-.8	2.1	13.0	35.8	30.9	9.0	6.3
	STD. DEV.	.6	.1	.1	.1	1.2	1.1	.5	5.8	4.5	1.5	9.0	4.5
MIS-B	1	.1	.4	.3	.3	3.6	.4	3.2	28.0	39.3	15.4	4.2	4.8
	3	.7	.5	.3	.3	3.0	1.3	.1	28.5	37.4	17.2	2.9	7.8
	5	.5	.5	.4	.4	3.9	-1.7	5.6	29.3	44.8	7.0	7.5	1.8
	MEAN	.4	.5	.3	.3	3.5	0.0	3.0	28.6	40.5	13.2	4.9	4.8
	STD. DEV.	.3	.1	.1	.1	.5	1.5	2.8	.7	3.8	5.4	2.4	3.0

Categorical Sediment Grain-Size Characterization
Survey 2

SURVEY 2 (CONTINUED)

STATION	SAMPLE NO.	>991	350-990	180-349	125-179	43-124	40-42	30-39	20-29	15-19	10-14	5-9	<5
		PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS)											
CS-A	1	.7	.5	1.3	2.7	4.8	0.0	1.1	14.3	31.9	29.3	10.7	2.7
	3	.9	1.1	2.9	4.0	4.4	2.3	1.5	.2	15.1	51.5	5.6	10.5
	5	1.3	1.0	2.3	3.7	5.5	-1.0	1.1	5.6	54.9	19.8	-4.6	10.4
	MEAN	1.0	.9	2.2	3.5	4.9	.4	1.2	6.7	34.0	33.5	3.9	7.9
	STD. DEV.	.3	.3	.8	.7	.6	1.7	.2	7.1	20.0	16.3	7.8	4.5
CS-B	1	.4	.9	7.6	12.0	8.3	-.2	.1	6.8	30.9	25.5	4.9	2.8
	3	3.0	2.8	27.4	18.6	6.2	.5	0.0	14.9	-1.0	16.5	9.0	2.1
	5	.7	.9	3.8	4.9	6.9	2.8	-2.5	4.7	17.7	54.8	4.0	1.3
	MEAN	1.4	1.5	12.9	11.8	7.1	1.0	-.8	8.8	15.9	32.3	6.0	2.1
	STD. DEV.	1.4	1.1	12.7	6.9	1.1	1.6	1.5	5.4	16.0	20.0	2.7	.8

Categorical Sediment Grain-Size Characterization
Survey 2

SURVEY 2 (CONTINUED)

PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS)

STATION	SAMPLE NO.	>991	350-990	180-349	125-179	43-124	40-42	30-39	20-29	15-19	10-14	5-9	<5
ALC	1	0.0	.1	.3	.3	5.0	-.6	3.7	4.3	10.4	40.4	32.1	4.0
	3	.1	.2	.7	.6	7.7	-2.0	-.7	8.2	18.7	61.9	-2.0	6.6
	5	2.7	5.2	11.1	2.7	7.9	.9	-5.7	4.5	30.0	36.6	3.5	.6
	MEAN	.9	1.8	4.0	1.2	6.9	-.6	-.9	5.7	19.7	46.3	11.2	3.7
	STD. DEV.	1.5	2.9	6.1	1.3	1.6	1.5	4.7	2.2	9.8	13.6	18.3	3.0
OIH	1	1.3	2.5	29.8	22.3	12.8	.6	1.9	5.8	10.8	7.4	2.7	2.1
	3	.9	2.3	33.2	24.4	12.9	-.3	2.0	3.0	7.2	7.5	6.5	.4
	5	.9	2.8	29.7	21.5	12.3	.1	2.3	3.8	14.5	8.8	1.5	1.8
	MEAN	1.0	2.5	30.9	22.7	12.7	.1	2.1	4.2	10.8	7.9	3.6	1.4
	STD. DEV.	.2	.3	2.0	1.5	.3	.5	.2	1.4	3.7	.8	2.6	.9

Categorical Sediment Grain-Size Characterization
Survey 2

SURVEY 2 (CONTINUED)

STATION	SAMPLE NO.	PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS) >991	350-990	180-349	125-179	43-124	40-42	30-39	20-29	15-19	10-14	5-9	<5
HP	1	25.5	2.6	1.3	2.2	9.2	.3	5.0	2.3	12.1	25.5	9.7	4.3
	3	6.5	1.4	1.6	4.2	12.0	1.4	2.0	13.8	25.8	21.5	9.5	.3
	5	8.2	1.5	1.7	3.9	10.9	1.1	5.6	8.4	27.6	17.2	5.3	8.6
	MEAN	13.4	1.8	1.5	3.4	10.7	.9	4.2	8.2	21.8	21.4	8.2	4.4
	STD. DEV.	10.5	.7	.2	1.1	1.4	.6	1.9	5.8	8.5	4.2	2.5	4.2
SB-A	1	25.4	16.3	11.9	3.4	4.6	1.1	.3	4.5	4.6	22.5	5.3	.1
	3	21.2	18.5	10.7	2.8	3.4	0.0	1.8	1.4	3.1	24.0	10.8	2.3
	5	45.5	19.2	10.5	2.2	2.8	.1	-.8	3.1	.4	15.1	1.9	0.0
	MEAN	30.7	18.0	11.0	2.8	3.6	.4	.4	3.0	2.7	20.5	6.0	.8
	STD. DEV.	13.0	1.5	.8	.6	.9	.6	1.3	1.6	2.1	4.0	4.5	1.3

SURVEY 2 (CONTINUED)

STATION	SAMPLE NO.	PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS) >991	350-990	180-349	125-179	43-124	40-42	30-39	20-29	15-19	10-14	5-9	<5
SB-8	1	7.3	1.9	1.8	1.5	5.7	-2.3	6.0	3.8	13.0	46.9	12.4	4.0
	3	0.0	.1	0.0	.1	6.2	-5.0	7.2	4.6	20.8	60.6	1.0	4.4
	5	.1	.2	.1	.1	4.9	-3.3	.5	4.3	28.6	47.3	17.1	.1
	MEAN	2.5	.7	.6	.6	5.6	-3.5	4.6	4.2	20.8	50.9	10.2	2.8
	STD. DEV.	4.2	1.0	1.0	.8	.7	1.4	3.6	.4	7.8	8.5	8.3	2.4
RCH-A	1	.5	1.7	16.2	7.3	2.8	.1	2.7	4.0	26.5	27.9	6.3	4.0
	3	6.6	1.2	4.7	2.6	5.5	-3.0	1.4	8.0	23.8	40.4	3.9	4.9
	5	1.4	.5	.6	.6	1.8	.6	-3.5	11.3	27.0	51.4	6.0	2.3
	MEAN	2.8	1.1	7.2	3.5	3.4	-.8	.2	7.8	25.8	39.9	5.4	3.7
	STD. DEV.	3.3	.6	8.1	3.4	1.9	2.0	3.3	3.7	1.7	11.8	1.3	1.3

Categorical Sediment Grain-Size Characterization
Survey 2

SURVEY 2 (CONTINUED)

STATION	SAMPLE NO.	>991	350-990	180-349	125-179	43-124	40-42	30-39	20-29	15-19	10-14	5-9	<5
		PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS)											
RCH-B	1	.1	.2	.1	.2	1.8	-.5	.3	10.7	40.7	35.3	7.7	3.4
	3	0.0	.5	.4	.2	1.5	.3	4.4	25.9	49.1	10.5	1.7	5.5
	5	.6	.4	.4	.4	2.2	2.7	-3.5	27.0	49.7	4.0	7.5	8.6
	MEAN	.2	.4	.3	.3	1.8	.8	.4	21.2	46.5	16.6	5.6	5.8
	STD. DEV.	.3	.2	.2	.1	.4	1.7	4.0	9.1	5.0	16.5	3.4	2.6

Categorical Sediment Grain-Size Characterization
Survey 3

SURVEY NO. 3
PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS)

STATION	SAMPLE NO.	>991	350-990	180-349	125-179	43-124	40-42	30-39	20-29	15-19	10-14	5-9	<5
MIS-A	1	0.0	1.0	.6	.4	2.3	.2	3.9	3.1	6.8	8.9	13.7	59.1
	2	0.0	.6	.5	.2	1.6	8.4	-7.4	2.7	2.9	10.4	17.3	62.8
	3	0.0	.2	.4	.3	1.5	1.5	5.3	4.7	5.3	7.8	12.6	60.4
	MEAN	0.0	.6	.5	.3	1.8	3.4	.6	3.5	5.0	9.0	14.5	60.8
	STD. DEV.	0.0	.4	.1	.1	.4	4.4	7.0	1.1	2.0	1.3	2.5	1.9
MIS-B	1	.1	.6	.6	.5	3.9	1.2	1.7	6.2	7.5	9.5	12.5	55.7
	2	.1	.9	.7	.6	4.4	5.9	2.0	6.9	3.4	8.0	13.9	53.2
	3	0.0	.9	.7	.4	3.1	.4	2.1	5.9	6.1	8.8	13.0	58.6
	MEAN	.1	.8	.7	.5	3.8	2.5	1.9	6.3	5.7	8.8	13.1	55.8
	STD. DEV.	.1	.2	.1	.1	.7	3.0	.2	.5	2.1	.8	.7	2.7

Categorical Sediment Grain-Size Characterization
Survey 3

SURVEY 3 (CONTINUED)

STATION	SAMPLE NO.	PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS) >991	350-990	180-349	125-179	43-124	40-62	30-39	20-29	15-19	10-14	5-9	<5
CS-A	1	1.4	9.2	35.5	22.3	6.9	.4	.8	2.9	.7	2.0	3.5	14.4
	2	1.3	14.9	43.5	20.2	3.6	.8	.3	.6	.9	.7	1.7	11.5
	3	4.6	13.5	35.1	18.1	3.6	1.1	.4	1.7	1.6	1.8	3.4	15.1
	MEAN	2.4	12.5	38.0	20.2	4.7	.8	.5	1.7	1.1	1.5	2.9	13.7
	STD. DEV.	1.9	3.0	4.7	2.1	1.9	.4	.3	1.2	.5	.7	1.0	1.9
CS-B	1	2.0	3.5	31.6	17.0	6.8	.2	.3	1.5	5.9	3.3	2.5	25.4
	2	.8	2.3	19.9	11.7	5.9	1.9	.6	3.2	4.2	4.9	7.9	36.7
	3	.6	3.3	30.2	14.6	5.3	.3	1.4	2.0	3.3	3.3	6.5	29.2
	MEAN	1.1	3.0	27.2	14.4	6.0	.8	.8	2.2	4.5	3.8	5.6	30.4
	STD. DEV.	.8	.6	6.4	2.7	.8	1.0	.6	.9	1.3	.9	2.8	5.8

Categorical Sediment Grain-Size Characterization
Survey 3

SURVEY 3 (CONTINUED)

PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS)

STATION	SAMPLE NO.	>991	350-990	180-349	125-179	43-124	40-42	30-39	20-29	15-19	10-14	5-9	<5
ALC	1	2.9	.6	4.7	3.3	3.7	6.7	5.7	5.5	4.6	6.6	10.6	45.1
	3	.8	.5	1.7	1.2	3.2	.1	4.6	6.6	6.1	6.7	13.4	55.1
	4	5.1	.8	4.5	2.2	4.5	1.5	.9	7.2	5.3	7.0	11.7	49.3
	MEAN	2.9	.6	3.6	2.2	3.8	2.8	3.7	6.4	5.3	6.8	11.9	49.8
	STD. DEV.	2.2	.2	1.7	1.1	.7	3.5	2.5	.9	.8	.2	1.4	5.0
DIH	1	.2	1.6	26.3	22.8	12.6	2.3	2.8	1.2	2.8	1.9	5.6	19.9
	2	.5	2.1	31.0	20.9	10.4	.9	1.7	2.3	.3	3.6	5.6	20.7
	3	.7	1.5	26.5	22.7	12.6	3.4	-.1	3.4	2.3	2.0	4.1	20.9
	MEAN	.5	1.7	27.9	22.1	11.9	2.2	1.5	2.3	1.8	2.5	5.1	20.5
	STD. DEV.	.3	.3	2.7	1.1	1.3	1.3	1.5	1.1	1.3	1.0	.9	.5

Categorical Sediment Grain-Size Characterization
Survey 3

SURVEY 3 (CONTINUED)

STATION	SAMPLE NO.	PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS) >991	350-990	180-349	125-179	43-124	40-42	30-39	20-29	15-19	10-14	5-9	<5
HP	1	3.9	1.7	2.4	3.3	8.7	7.6	.5	7.5	4.5	6.2	10.3	43.4
	2	.2	1.3	3.3	6.5	14.4	4.3	3.6	5.3	5.5	4.4	9.2	42.0
	3	7.3	1.0	0.0	3.8	12.5	4.9	4.0	-.9	6.9	5.0	9.3	46.2
	MEAN	3.8	1.3	1.9	4.5	11.9	5.6	2.7	4.0	5.6	5.2	9.6	43.9
	STD. DEV.	3.6	.4	1.7	1.7	2.9	1.8	1.9	4.4	1.2	.9	.6	2.1
SB-A	1	.1	.3	.5	.3	1.6	9.8	.4	6.7	8.3	5.9	12.1	54.0
	2	3.0	.7	.9	.6	6.0	-2.4	11.9	-.7	7.6	7.4	10.3	54.7
	3	4.0	1.2	1.2	.9	3.6	6.5	1.5	5.3	6.3	5.7	10.8	52.7
	MEAN	2.4	.7	.9	.6	3.7	4.6	4.7	3.8	7.4	6.3	11.1	53.8
	STD. DEV.	2.0	.5	.4	.3	2.2	6.3	6.3	3.9	1.0	.9	.9	1.0

Categorical Sediment Grain-Size Characterization
Survey 3

SURVEY 3 (CONTINUED)

STATION	SAMPLE NO.	PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS) >991	350-990	180-349	125-179	43-124	40-42	30-39	20-29	15-19	10-14	5-9	<5
SB-B	1	3.[illegible]	.9	.7	.6	2.5	1.8	4.4	8.2	5.4	8.4	13.0	50.5
	2	.3	.4	.6	.6	2.7	.5	7.7	7.3	5.8	4.1	17.0	53.0
	3	.3	.5	.6	.5	2.4	1.6	2.1	2.7	6.5	8.2	14.0	60.6
	MEAN	1.4	.6	.6	.6	2.5	1.3	4.7	6.1	5.9	6.9	14.7	54.7
	STD. DEV.	1.9	.3	.1	.1	.2	.7	2.8	3.0	.6	2.4	2.1	5.3
RCH-A	1	1.1	.6	.6	1.7	3.9	.1	3.7	5.4	6.8	7.5	9.3	59.3
	2	.9	.4	.6	1.7	3.5	1.4	3.8	2.3	9.7	6.4	13.3	56.0
	3	5.5	.9	1.1	1.9	3.6	1.1	4.0	6.5	6.8	4.6	11.5	52.5
	MEAN	2.5	.6	.8	1.8	3.7	.9	3.8	4.7	7.8	6.2	11.4	55.9
	STD. DEV.	2.6	.3	.3	.1	.2	.7	.2	2.2	1.7	1.5	2.0	3.4

Categorical Sediment Grain-Size Characterization
Survey 3

SURVEY 3 (CONTINUED)

STATION	SAMPLE NO.	PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS) >991	350-990	180-349	125-179	43-124	40-42	30-39	20-29	15-19	10-14	5-9	<5
RCH-8	1	.5	.8	.6	.4	2.3	2.1	2.0	3.2	9.0	6.2	13.1	60.0
	2	.4	.4	.5	.3	2.2	5.2	.7	.5	6.8	3.6	16.9	62.5
	3	.2	.5	.3	.2	1.7	3.4	4.6	6.6	5.4	6.5	12.1	58.5
	MEAN	.4	.5	.5	.3	2.1	3.6	2.4	3.4	7.1	5.4	14.0	60.3
	STD. DEV.	.2	.1	.2	.1	.3	1.6	2.0	3.1	1.8	1.6	2.5	2.0

Categorical Sediment Grain-Size Characterization
Survey 4

SURVEY NO. 4
PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS)

STATION	SAMPLE NO.	>991	350-990	180-349	125-179	43-124	40-42	30-39	20-29	15-19	10-14	5-9	<5
MIS-A	1	0.0	.4	.4	.2	.8	.7	.5	4.3	5.5	6.2	16.7	64.3
	2	0.0	.5	.2	.1	.1	3.9	-1.2	4.3	5.6	6.7	16.0	63.8
	3	0.0	.3	.3	.2	.2	.3	1.8	.4	5.1	9.7	40.0	41.7
	MEAN	0.0	.4	.3	.2	.4	1.6	.4	3.0	5.4	7.5	24.2	56.6
	STD. DEV.	0.0	.1	.1	.1	.4	2.0	1.5	2.3	.3	1.9	13.7	12.9
MIS-B	1	1.6	.5	.4	.3	2.0	.1	4.6	4.8	7.0	6.1	20.6	52.0
	2	.1	.5	.3	.3	2.1	1.6	2.9	6.0	4.8	8.6	16.3	56.5
	3	0.0	.4	.3	.2	.1	.2	3.4	4.8	8.3	8.6	20.3	53.4
	MEAN	.6	.5	.3	.3	1.4	.6	3.6	5.2	6.7	7.8	19.1	54.0
	STD. DEV.	.9	.1	.1	.1	1.1	.8	.9	.7	1.8	1.4	2.4	2.3

Categorical Sediment Grain-Size Characterization
Survey 4

SURVEY 4 (CONTINUED)

PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS)

STATION	SAMPLE NO.	>991	350-990	180-349	125-179	43-124	40-42	30-39	20-29	15-19	10-14	5-9	<5
CS-A	1	1.9	1.2	7.3	6.8	5.6	-.9	.5	6.4	3.7	15.5	5.4	46.6
	2	.4	1.4	8.2	5.5	6.3	-2.7	2.4	4.9	5.7	6.6	12.5	48.8
	3	3.7	4.8	25.7	18.6	4.8	-1.4	-.5	3.3	3.6	3.7	7.2	26.5
	MEAN	2.0	2.5	13.7	10.3	5.6	-1.7	.8	4.9	4.3	8.6	8.4	40.6
	STD. DEV.	1.7	2.0	10.4	7.2	.8	.9	1.5	1.6	1.2	6.1	3.7	12.3
CS-B	1	.5	2.4	11.5	18.8	18.0	1.8	.9	2.8	3.5	3.8	6.7	29.3
	2	.4	1.5	10.5	20.1	18.2	1.7	.2	2.6	2.8	4.2	7.6	30.2
	3	.2	1.3	16.5	-4.9	41.5	.8	1.4	2.3	2.6	3.3	6.1	28.9
	MEAN	.4	1.7	12.8	11.3	25.9	1.4	.8	2.6	3.0	3.8	6.8	29.5
	STD. DEV.	.2	.6	3.2	14.1	13.5	.6	.6	.3	.5	.5	.8	.7

SURVEY 4 (CONTINUED)

PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS)

STATION	SAMPLE NO.	>991	350-990	180-349	125-179	43-124	40-42	30-39	20-29	15-19	10-14	5-9	<5
ALC	1	0.0	7.7	72.2	18.2	1.2	.4	.2	0.0	0.0	0.0	0.0	.1
	2	.1	11.0	74.3	13.6	.7	0.0	.1	.1	0.0	0.0	0.0	.1
	3	0.0	6.0	75.0	17.6	.9	.1	0.0	.2	0.0	.1	.1	0.0
	MEAN	.0	8.2	73.8	16.5	.9	.2	.1	.1	0.0	.0	.0	.1
	STD. DEV.	.1	2.5	1.5	2.5	.3	.2	.1	.1	0.0	.1	.1	.1
OIH	1	.5	4.5	35.6	17.4	10.6	1.1	.2	2.0	2.0	2.7	5.6	17.8
	2	1.9	4.5	34.7	16.8	9.1	2.0	.6	2.7	2.4	2.7	3.8	18.8
	3	1.1	3.9	30.6	16.9	10.5	1.7	3.1	1.3	2.9	2.9	4.3	20.8
	MEAN	1.2	4.3	33.6	17.0	10.1	1.6	1.3	2.0	2.4	2.8	4.6	19.1
	STD. DEV.	.7	.3	2.7	.3	.8	.5	1.6	.7	.5	.1	.9	1.5

Categorical Sediment Grain-Size Characterization
Survey 4

SURVEY 4 (CONTINUED)

PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS)

STATION	SAMPLE NO.	>991	350-990	180-349	125-179	43-124	40-42	30-39	20-29	15-19	10-14	5-9	<5
HP	1	1.2	1.2	1.8	3.3	12.7	1.3	.5	7.8	6.9	2.5	8.0	52.8
	2	6.6	1.6	1.9	2.8	10.1	6.0	.9	2.0	8.0	.7	9.2	50.2
	3	.2	1.6	2.0	2.7	9.4	6.4	-.9	6.2	5.5	6.7	9.0	51.2
	MEAN	2.7	1.5	1.9	2.9	10.7	4.6	.2	5.3	6.8	3.3	8.7	51.4
	STD. DEV.	3.4	.2	.1	.3	1.7	2.8	.9	3.0	1.3	3.1	.6	1.3
SB-A	1	10.1	13.0	12.1	.9	1.0	4.1	.8	3.5	4.1	6.2	10.8	33.4
	2	.3	.8	1.1	.6	2.9	1.9	4.5	9.2	8.0	7.9	11.2	51.6
	3	17.7	15.5	13.7	1.7	3.3	-1.5	.5	4.8	3.6	3.5	7.8	25.4
	MEAN	9.4	11.1	9.0	1.1	2.4	1.5	1.9	5.8	5.2	5.9	9.9	36.8
	STD. DEV.	8.7	9.5	6.9	.6	1.2	2.8	2.2	3.0	2.4	2.2	1.9	13.4

Categorical Sediment Grain-Size Characterization
Survey 4

SURVEY 4 (CONTINUED)

PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS)

STATION	SAMPLE NO.	>991	350-990	180-349	125-179	43-124	40-42	30-39	20-29	15-19	10-14	5-9	<5
SB-B	1	1.0	.5	.4	.3	1.8	4.6	1.6	7.2	9.5	8.8	16.6	47.7
	2	0.0	.7	.6	.5	.6	7.1	44.4	29.3	4.3	2.9	4.6	5.0
	3	0.0	.8	.5	.3	.6	5.6	3.9	7.8	14.0	11.2	20.7	34.6
	MEAN	.3	.7	.5	.4	1.0	5.8	16.6	14.8	9.3	7.6	14.0	29.1
	STD. DEV.	.6	.2	.1	.1	.7	1.3	24.1	12.6	4.9	4.3	8.4	21.9
RCH-A	1	7.5	3.3	8.0	10.8	5.9	1.6	1.4	5.3	3.3	4.5	8.0	40.4
	2	9.1	2.5	5.2	6.1	3.4	0.0	1.4	6.3	5.4	5.2	9.4	46.0
	3	10.0	3.9	6.1	6.7	1.5	1.5	3.1	3.5	4.0	5.7	9.2	44.8
	MEAN	8.9	3.2	6.4	7.9	3.6	1.0	2.0	5.0	4.2	5.1	8.9	43.7
	STD. DEV.	1.3	.7	1.4	2.6	2.2	.9	1.0	1.4	1.1	.6	.8	2.9

Categorical Sediment Grain-Size Characterization
Survey 4

SURVEY 4 (CONTINUED)

PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS)

STATION	SAMPLE NO.	>991	350-990	180-349	125-179	43-124	40-42	30-39	20-29	15-19	10-14	5-9	<5
RCH-8	1	.1	.4	.2	.2	1.3	.3	3.7	7.4	6.2	7.1	11.9	61.2
	2	.1	.8	.4	.2	1.7	6.6	-1.3	7.0	5.6	8.1	11.9	58.9
	3	.3	.4	.3	.3	1.7	1.1	1.6	8.5	6.3	7.8	12.6	59.1
	MEAN	.2	.5	.3	.2	1.6	2.7	1.3	7.6	6.0	7.7	12.1	59.7
	STD. DEV.	.1	.2	.1	.1	.2	3.4	2.5	.8	.4	.5	.4	1.3

HEAVY-METAL CONCENTRATION

Heavy-Metal Concentration
Survey P

PRELIMINARY SURVEY

STATION	SAMPLE NO.	COPPER (MG/KG)	CADMIUM (MG/KG)	LEAD (MG/KG)	ZINC (MG/KG)	MERCURY (MG/KG)
MIS-A	1	39.4	.87	21.3	--	--
	2	48.2	1.07	22.0	--	--
	3	52.8	.94	21.6	--	--
	4	57.9	1.04	24.6	--	--
	MEAN	49.6	.98	22.4	--	--
	STD. DEV.	7.9	.09	1.5	--	--
MIS-B	1	51.2	1.06	25.7	--	--
	2	63.0	1.13	24.1	--	--
	3	52.2	.84	20.2	--	--
	4	59.6	.98	21.1	--	--
	5	58.9	.94	21.8	--	--
	MEAN	57.0	.99	22.6	--	--
	STD. DEV.	5.1	.11	2.3	--	--

PRELIMINARY SURVEY (CONTINUED)

STATION	SAMPLE NO.	COPPER (MG/KG)	CADMIUM (MG/KG)	LEAD (MG/KG)	ZINC (MG/KG)	MERCURY (MG/KG)
CS-A	1	120.9	2.25	51.3	--	--
	2	97.1	1.59	43.7	--	--
	3	95.5	1.28	41.4	--	--
	4	90.7	1.57	35.1	--	--
	5	86.9	1.75	42.7	--	--
	MEAN	98.2	1.69	42.8	--	--
	STD. DEV.	13.3	.36	5.9	--	--
CS-B	1	65.6	1.84	27.1	--	--
	2	66.2	2.25	37.8	--	--
	3	81.6	2.13	36.1	--	--
	4	85.0	2.45	38.2	--	--
	5	72.1	1.67	36.1	--	--
	MEAN	74.3	2.11	35.1	--	--
	STD. DEV.	9.2	.26	4.6	--	--
ALC	1	23.5	1.58	--	--	--
	2	55.2	1.63	47.9	--	--
	3	27.6	1.96	46.7	--	--
	MEAN	35.4	1.72	47.3	--	--
	STD. DEV.	17.2	.21	0.8	--	--

PRELIMINARY SURVEY (CONTINUED)

STATION	SAMPLE NO.	COPPER (MG/KG)	CADMIUM (MG/KG)	LEAD (MG/KG)	ZINC (MG/KG)	MERCURY (MG/KG)
OIH	1	73.4	2.38	77.8	--	--
	2	100.2	2.37	72.4	--	--
	3	85.6	2.49	78.4	--	--
	4	96.7	2.79	85.5	--	--
	5	93.0	2.18	71.2	--	--
	MEAN	89.8	2.44	77.1	--	--
	STD. DEV.	10.6	.22	5.7	--	--
HP	1	73.3	1.34	50.3	--	--
	2	76.5	1.54	46.6	--	--
	3	60.2	1.22	36.0	--	--
	4	72.5	1.43	44.7	--	--
	5	74.7	1.38	45.5	--	--
	MEAN	71.4	1.38	44.6	--	--
	STD. DEV.	6.5	.12	5.3	--	--

PRELIMINARY SURVEY (CONTINUED)

STATION	SAMPLE NO.	COPPER (MG/KG)	CADMIUM (MG/KG)	LEAD (MG/KG)	ZINC (MG/KG)	MERCURY (MG/KG)
SB-A WAS NOT ANALYZED						
SB-B	1	49.0	1.16	26.0	--	--
	2	63.9	1.13	35.4	--	--
	3	46.0	.88	29.9	--	--
	4	54.9	.88	30.7	--	--
	5	44.4	.76	27.4	--	--
	MEAN	51.6	.96	29.9	--	--
	STD. DEV.	7.9	.17	3.6	--	--
RCH-A WAS NOT ANALYZED						
RCH-B	1	61.7	1.28	34.8	--	--
	2	50.9	1.04	24.6	--	--
	3	49.9	1.02	30.0	--	--
	4	57.0	.67	19.0	--	--
	5	49.4	1.05	29.8	--	--
	MEAN	53.8	1.01	27.6	--	--
	STD. DEV.	5.4	.22	6.0	--	--

Heavy-Metal Concentration
Survey 1

SURVEY NO. 1

STATION	SAMPLE NO.	COPPER (MG/KG)	CADMIUM (MG/KG)	LEAD (MG/KG)	ZINC (MG/KG)	MERCURY (MG/KG)
MIS-A	1	50.8	.66	19.8	--	--
	2	75.5	1.04	35.4	--	--
	3	54.7	.88	23.0	--	--
	MEAN	60.3	.86	26.1	--	--
	STD. DEV.	13.3	.19	8.2	--	--
MIS-B	3	70.0	1.07	31.7	--	--
	4	56.7	.96	25.2	--	--
	5	57.4	.96	28.4	--	--
	MEAN	61.4	1.00	28.4	--	--
	STD. DEV.	7.5	.06	3.3	--	--
CS-A	1	86.9	2.01	50.3	--	--
	3	101.2	2.06	50.7	--	--
	4	96.3	1.74	50.2	--	--
	MEAN	94.8	1.94	50.4	--	--
	STD. DEV.	7.3	.17	.3	--	--

SURVEY NO. 1 (CONTINUED)

STATION	SAMPLE NO.	COPPER (MG/KG)	CADMIUM (MG/KG)	LEAD (MG/KG)	ZINC (MG/KG)	MERCURY (MG/KG)
CS-B	1	85.8	1.93	56.7	--	--
	2	35.1	1.39	23.6	--	--
	3	115.1	2.12	75.4	--	--
	MEAN	95.3	1.81	51.9	--	--
	STD. DEV.	17.1	.38	26.2	--	--
ALC	2	15.2	1.28	30.2	--	--
	4	17.9	1.46	31.0	--	--
	5	17.6	1.47	41.6	--	--
	MEAN	16.9	1.40	34.3	--	--
	STD. DEV.	1.5	.11	6.4	--	--
OIH	2	69.7	2.18	67.8	--	--
	3	70.4	2.47	66.5	--	--
	6	127.2	3.17	94.5	--	--
	MEAN	89.1	2.61	76.3	--	--
	STD. DEV.	33.0	.51	15.8	--	--

Heavy-Metal Concentration
Survey 1

SURVEY NO. 1 (CONTINUED)

STATION	SAMPLE NO.	COPPER (MG/KG)	CADMIUM (MG/KG)	LEAD (MG/KG)	ZINC (MG/KG)	MERCURY (MG/KG)
HP	3	51.3	1.37	65.9	--	--
	5	62.0	1.21	41.8	--	--
	6	52.6	1.09	36.5	--	--
	MEAN	55.3	1.22	48.1	--	--
	STD. DEV.	5.8	.14	15.7	--	--
SB-A WAS NOT ANALYZED						
SB-B	2	45.9	1.45	27.8	--	--
	3	35.6	.93	21.8	--	--
	4	44.3	1.26	25.8	--	--
	MEAN	41.9	1.21	25.1	--	--
	STD. DEV.	5.5	.26	3.1	--	--
RCH-A WAS NOT ANALYZED						
RCH-B	2	67.5	1.51	47.8	--	--
	3	54.6	1.14	37.4	--	--
	4	47.6	1.10	35.9	--	--
	MEAN	56.6	1.25	40.4	--	--
	STD. DEV.	10.1	.23	6.5	--	--

SURVEY NO. 2

STATION	SAMPLE NO.	COPPER (MG/KG)	CADMIUM (MG/KG)	LEAD (MG/KG)	ZINC (MG/KG)	MERCURY (MG/KG)
MIS-A	1	36.0	.90	24.0	80.0	.44
	2	77.0	1.40	38.0	178.0	.24
	3	30.0	.66	18.0	63.0	.28
	MEAN	47.7	.99	26.7	107.0	.32
	STD. DEV.	25.6	.38	10.3	62.1	.11
MIS-B	1	31.0	.85	26.0	79.0	.79
	2	50.0	.69	29.0	130.0	.28
	3	51.0	.58	23.0	146.0	.24
	MEAN	44.0	.71	26.0	118.3	.44
	STD. DEV.	11.3	.14	3.0	35.0	.31
CS-A	[illegible]	50.0	1.80	48.0	156.0	.34
	[illegible]	63.0	1.20	41.0	145.0	.45
	[illegible]	51.0	.82	31.0	125.0	--
	MEAN	54.7	1.27	40.0	142.0	.39
	STD. DEV.	7.2	.49	8.5	15.7	.08

SURVEY NO. 2 (CONTINUED)

STATION	SAMPLE NO.	COPPER (MG/KG)	CADMIUM (MG/KG)	LEAD (MG/KG)	ZINC (MG/KG)	MERCURY (MG/KG)
CS-B	1	39.0	.97	31.0	112.0	.23
	2	40.0	1.30	34.0	107.0	.25
	3	38.0	.94	25.0	117.0	.29
	MEAN	39.0	1.07	30.0	112.0	.26
	STD. DEV.	1.0	.20	4.6	5.0	.03
ALC	1	33.0	1.50	21.0	97.0	.07
	2	21.0	.50	6.9	63.0	.06
	3	15.0	.92	11.0	72.0	.07
	MEAN	23.0	.97	13.0	77.3	.07
	STD. DEV.	9.2	.50	7.3	17.6	.01
OIH	1	32.0	.98	35.0	117.0	.40
	2	28.0	.99	41.0	127.0	.34
	3	25.0	.71	29.0	101.0	.33
	MEAN	28.3	.89	35.0	115.0	.36
	STD. DEV.	3.5	.16	6.0	13.1	.04

SURVEY NO. 2 (CONTINUED)

STATION	SAMPLE NO.	COPPER (MG/KG)	CADMIUM (MG/KG)	LEAD (MG/KG)	ZINC (MG/KG)	MERCURY (MG/KG)
HP	1	56.0	1.20	47.0	166.0	.41
	2	31.0	1.10	41.0	130.0	.22
	3	40.0	.74	34.0	139.0	.20
	MEAN	42.3	1.01	40.7	145.0	.28
	STD. DEV.	12.7	.24	6.5	18.7	.12
SB-A WAS NOT ANALYZED						
SB-B	1	26.0	.97	37.0	113.0	.22
	2	35.0	.60	24.0	101.0	.46
	3	58.0	.76	34.0	163.0	.49
	MEAN	39.7	.78	31.7	125.7	.39
	STD. DEV.	16.5	.19	6.8	32.9	.15
RCH-A WAS NOT ANALYZED						
RCH-B	1	30.0	1.30	46.0	133.0	.24
	2	44.0	.97	40.0	135.0	.35
	3	31.0	.83	34.0	122.0	.08
	MEAN	35.0	1.03	40.0	130.0	.22
	STD. DEV.	7.8	.24	6.0	7.0	.14

Heavy-Metal Concentration
Survey 3

SURVEY NO. 3

STATION	SAMPLE NO.	COPPER (MG/KG)	CADMIUM (MG/KG)	LEAD (MG/KG)	ZINC (MG/KG)	MERCURY (MG/KG)
NIS-A	1	72.0	1.70	44.0	184.0	.15
	2	47.0	2.30	42.0	156.0	.16
	3	78.0	2.20	36.0	186.0	.11
	MEAN	65.7	2.07	40.7	175.3	.14
	STD. DEV.	16.4	.32	4.2	16.8	.03
NIS-B	1	62.0	1.60	46.0	166.0	.26
	2	69.0	1.70	40.0	164.0	.32
	3	61.0	1.70	56.0	169.0	.22
	MEAN	64.0	1.67	47.3	166.3	.27
	STD. DEV.	4.4	.06	8.1	2.5	.05
CS-A	1	29.0	.82	20.0	93.0	.02
	2	13.0	.71	19.0	77.0	.02
	3	23.0	.77	18.0	76.0	.01
	MEAN	21.7	.77	19.0	82.0	.02
	STD. DEV.	8.1	.06	1.0	9.5	.01

SURVEY NO. 3 (CONTINUED)

STATION	SAMPLE NO.	COPPER (MG/KG)	CADMIUM (MG/KG)	LEAD (MG/KG)	ZINC (MG/KG)	MERCURY (MG/KG)
CS-B	1	34.0	.96	28.0	104.0	.02
	2	46.0	.88	30.0	122.0	.36
	3	37.0	.95	30.0	102.0	.10
	MEAN	39.0	.93	29.3	109.3	.16
	STD. DEV.	6.2	.04	1.2	11.0	.12
ALC	1	29.0	1.30	26.0	93.0	.14
	2	32.0	1.20	24.0	96.0	.09
	3	32.0	1.20	25.0	80.0	.08
	MEAN	31.0	1.23	25.0	89.7	.10
	STD. DEV.	1.7	.06	1.0	8.5	.03
OIH	1	25.0	1.20	48.0	116.0	.03
	2	27.0	1.40	52.0	109.0	.49
	3	47.0	1.10	45.0	154.0	.38
	MEAN	33.0	1.23	48.3	126.3	.30
	STD. DEV.	12.2	.15	3.5	24.2	.24

SURVEY NO. 3 (CONTINUED)

STATION	SAMPLE NO.	COPPER (MG/KG)	CADMIUM (MG/KG)	LEAD (MG/KG)	ZINC (MG/KG)	MERCURY (MG/KG)
HP	1	50.0	.96	36.0	130.0	--
	2	48.0	1.50	46.0	140.0	--
	3	51.0	1.30	48.0	138.0	--
	MEAN	49.7	1.25	43.3	136.0	--
	STD. DEV.	1.5	.27	6.4	5.3	--
SB-A WAS NOT ANALYZED						
SB-B	1	28.0	1.30	37.0	108.0	.42
	2	28.0	1.20	40.0	107.0	.25
	3	31.0	.58	16.0	84.0	.03
	MEAN	29.0	1.03	31.0	99.7	.23
	STD. DEV.	1.7	.39	13.1	13.6	.20
RCH-A WAS NOT ANALYZED						
RCH-B	1	34.0	1.60	46.0	145.0	.01
	2	37.0	1.70	53.0	143.0	.02
	3	58.0	.91	39.0	156.0	.06
	MEAN	43.0	1.40	46.0	148.0	.03
	STD. DEV.	13.1	.43	7.0	7.0	.03

SURVEY NO. 4

STATION	SAMPLE NO.	COPPER (MG/KG)	CADMIUM (MG/KG)	LEAD (MG/KG)	ZINC (MG/KG)	MERCURY (MG/KG)
MIS-A	1	52.0	.75	25.0	121.0	.05
	2	49.0	.80	24.0	102.0	0.00
	3	48.0	.77	23.0	95.0	0.00
	MEAN	49.7	.77	24.0	106.0	.02
	STD. DEV.	2.1	.03	1.0	13.5	.03
MIS-B	1	53.0	.98	25.0	111.0	0.00
	2	47.0	.76	21.0	94.0	.01
	3	47.0	.74	20.0	86.0	.09
	MEAN	49.0	.83	22.0	97.0	.03
	STD. DEV.	3.5	.13	2.6	12.8	.05
CS-A	1	75.0	1.40	38.0	156.0	0.00
	2	54.0	1.40	29.0	119.0	.63
	3	70.0	1.50	35.0	130.0	0.00
	MEAN	66.3	1.43	34.0	151.7	.21
	STD. DEV.	11.0	.06	4.6	30.7	.36

SURVEY NO. 4 (CONTINUED)

STATION	SAMPLE NO.	COPPER (MG/KG)	CADMIUM (MG/KG)	LEAD (MG/KG)	ZINC (MG/KG)	MERCURY (MG/KG)
CS-B	1	57.0	1.40	45.0	144.0	.03
	2	53.0	.95	31.0	144.0	.15
	3	59.0	1.10	50.0	149.0	.43
	MEAN	56.3	1.15	42.0	145.7	.20
	STD. DEV.	3.1	.23	9.8	2.9	.21
ALC	1	13.0	1.10	32.0	80.0	.01
	2	12.0	.86	40.0	67.0	.13
	3	11.0	.88	29.0	60.0	.02
	MEAN	12.0	.95	33.7	69.0	.05
	STD. DEV.	1.0	.13	5.7	10.1	.07
OIH	1	92.0	2.70	94.0	268.0	0.00
	2	100.0	2.60	89.0	275.0	0.00
	3	59.0	1.30	60.0	173.0	.05
	MEAN	83.7	2.20	81.0	238.7	.02
	STD. DEV.	21.7	.78	18.4	57.0	.03

SURVEY NO. 4 (CONTINUED)

STATION	SAMPLE NO.	COPPER (MG/KG)	CADMIUM (MG/KG)	LEAD (MG/KG)	ZINC (MG/KG)	MERCURY (MG/KG)
HP	1	57.0	1.30	44.0	124.0	.81
	2	73.0	1.60	72.0	211.0	.22
	3	43.0	.82	33.0	134.0	0.00
	MEAN	57.7	1.24	51.3	157.7	.34
	STD. DEV.	15.0	.39	18.1	46.3	.42

SB-A WAS NOT ANALYZED

STATION	SAMPLE NO.	COPPER (MG/KG)	CADMIUM (MG/KG)	LEAD (MG/KG)	ZINC (MG/KG)	MERCURY (MG/KG)
SB-B	1	43.0	1.00	28.0	116.0	0.00
	2	28.0	.83	22.0	69.0	.72
	3	21.0	.61	16.0	58.0	.41
	MEAN	30.7	.81	22.0	81.0	.38
	STD. DEV.	11.2	.20	6.0	30.8	.36

RCH-A WAS NOT ANALYZED

STATION	SAMPLE NO.	COPPER (MG/KG)	CADMIUM (MG/KG)	LEAD (MG/KG)	ZINC (MG/KG)	MERCURY (MG/KG)
RCH-B	1	46.0	.89	35.0	119.0	.99
	2	37.0	.88	30.0	90.0	.07
	3	44.0	.86	32.0	112.0	.05
	MEAN	42.3	.88	32.3	107.0	.37
	STD. DEV.	4.7	.02	2.5	15.1	.53